

Essays in International Macroeconomics and Finance



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A thesis submitted for the degree of
Doctor of Philosophy in Economics

Trinity Term, 2026

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Abstract

This thesis documents novel facts and patterns in international macroeconomics and finance. It furthermore investigates their drivers through both theoretical and empirical methods, leveraging on public and confidential granular microeconomic data. The thesis consists of three papers, in the respective contexts of international financial sanctions, trade invoicing, and climate finance.

Chapter 1, *‘Sanctions and Currencies in Global Credit’*, studies how the 2014 EU-US sectoral sanctions against Russia changed the currency composition of international credit to the Russian economy. Using firm-, bank-, and loan-level data, it shows that sanctions triggered a sizeable shift away from dollar-denominated lending and towards euro-denominated credit, reflecting higher sanction-compliance risk in the dollar payment system. This chapter is co-authored with Giovanni Rosso and Roger Vicquéry.

Chapter 2, *‘Dominant Currency Pricing Transition’*, documents a striking shift in invoicing behaviour: the dollarisation of UK exports after the 2016 Brexit referendum. Using transaction-level customs data, it shows that large exchange-rate movements and firms’ currency mismatches can endogenously generate a transition towards dominant currency pricing, with important consequences for exchange-rate pass-through and trade elasticities. This chapter is also co-authored with Giovanni Rosso and Roger Vicquéry.

Chapter 3, *‘Greenback? Sustainable Investing and the International Transmission of Monetary Policy’*, studies how US monetary policy spillovers differ across foreign firms depending on their carbon emissions. Combining high-frequency monetary surprises with firm-level data on non-US firms, it shows that tighter US monetary policy disproportionately affects higher-emission firms, and provides evidence for both a green-preference channel and a limited risk-bearing-capacity channel.

Declarations

Supervision: the writing of this thesis was supervised by Professor Andrea Ferrero and Professor Francesco Zanetti.

Authorship: the first and second chapters of this thesis are co-authored with Giovanni Rosso and Roger Vicqu  ry; the third chapter is single-authored.

Declarations and acknowledgement of funding: no chapter in this thesis has been submitted for a degree at this or any other university.

Total words: this thesis contains 88,558 words in total.

Acknowledgements

To begin with, I would like to thank my phenomenal supervisors Andrea Ferrero and Francesco Zanetti. I have learned so much from you, in so many ways — I will be forever grateful for your guidance and mentorship.

My sincere and heartfelt thanks also go to all my co-authors, especially Giovanni Rosso and Roger Vicqu  ry. You have been the best “partners in crime” I could have wished for, and I look forward to many more papers and long nights spent on exciting research projects.

It would be foolish to try to give proper recognition to all the amazing colleagues and fantastic friends I met along the way during the past ten years I spent working at the Bank of England and five studying for my part-time DPhil at the Oxford Economics Department. So allow me simply to thank you all for making this period of my life just extraordinary, and turning me into the economist I am today.

Finally, I thank my ever-supporting family. My mother Patrizia, my father Massimo and brother Matteo — you have been a continuous source of encouragement. Nothing could have ever been possible without my wife Katja: your love, help, ambition and perseverance inspired me to this achievement, and keep inspiring me every day.

Contents

List of Figures	x
List of Tables	xvii
1 Sanctions and Currencies in Global Credit	1
1.1 Introduction	2
1.2 Jurisdiction and Currency Frictions in the 2014 Financial Sanctions on Russia	12
1.2.1 Jurisdiction-specific Frictions	12
1.2.2 Currency-specific Frictions	16
1.3 Data	23
1.4 The Effect of the 2014 Financial “Sectoral” Sanctions on Russian Firms’ Balance Sheets	28
1.4.1 Stylised Facts on Russian Firms after the 2014 Sectoral Sanc- tions	28
1.4.2 The Effect of the 2014 Sectoral Sanctions on Debt Levels and Currency Denomination	30
1.5 Jurisdiction and Currency Frictions in Bank-Level Lending to Russia after 2014	36
1.5.1 Stylised Facts	36
1.5.2 Bank-Level Margin Decomposition of Euro Claims to Russia	38
1.5.3 A Bank-level Empirical Analysis of Sanction-risk Driven Jur- isdiction and Currency Frictions	42
1.6 Evidence on Prices and Quantities from the Russian Syndicated Loans Market	58

1.6.1	Stylised Facts	58
1.6.2	Disentangling Jurisdiction and Currency Margins in Loan Prices and Quantities	59
1.6.3	Prices, Quantities and the Substitutability of Vehicle Curren- cies in International Credit Flows	64
1.7	A Capital Flows View of Geo-economic Power	70
1.7.1	Share of Controlled Capital Flows	71
1.8	Conclusion	75
2	Dominant Currency Pricing Transition	77
2.1	Introduction	78
2.2	Data and key mechanism	84
2.2.1	Data	85
2.2.2	Background: The 2016 Pound “Crash”	88
2.2.3	Currency mismatch, sudden exchange-rate depreciation and valuation effects	90
2.3	Transaction-level empirical analysis	94
2.3.1	Static regression analysis	95
2.3.2	Dynamic event-study analysis	97
2.4	Main Results	98
2.4.1	Static regression analysis	98
2.4.2	Dynamics	100
2.4.3	Quantitative importance	101
2.4.4	The role of market power	102
2.5	Macroeconomic implications of dominant currency pricing transition	107
2.5.1	Have Allocative Properties of Export Price Rigidity Changed?	108
2.6	Conclusion	109

3	Greenback? Sustainable Investing and the International Transmission of Monetary Policy	112
3.1	Introduction	113
3.2	Data	125
3.2.1	Monetary Policy Surprises	126
3.2.2	Firm-Level Information	126
3.2.3	Investor-Firm Capital Flows	133
3.3	New Evidence on Carbon Emissions and the International Transmission of US Monetary Policy	135
3.3.1	Stock Prices	136
3.3.2	Credit Spreads	139
3.3.3	Debt	141
3.3.4	Investment	143
3.4	A Stylised Model of Global Investors with Climate Risk and Green Preferences	146
3.4.1	Model Set-Up	148
3.4.2	Sustainable Investing and Monetary Policy Spillovers	151
3.5	Identifying the Mechanisms	152
3.5.1	Identification Strategy	152
3.5.2	Empirical Specification	154
3.5.3	Results	155
3.5.4	Robustness	156
3.6	Conclusion	159

Appendices

A	Appendix to Chapter 1	163
A.1	Additional Stylised Facts on Aggregate Capital Flows and the 2014 Sectoral Sanctions Against Russia	163
A.2	Appendix to the Firm-Level Empirical Analysis	166
A.3	Appendix to the UK Resident Bank-level Empirical Analysis	173

A.4	Appendix to the Syndicated Loan Empirical Analysis	190
A.4.1	Stylised Facts	190
A.4.2	Additional Empirical Evidence	190
A.5	Appendix to the Capital Flows View of Geo-economic Power	194
B	Appendix to Chapter 2	195
B.1	Data: Stylised Facts	195
B.2	Empirics: robustness checks	206
C	Appendix to Chapter 3	218
C.1	Data	219
C.1.1	Data sources	219
C.1.2	Data Cleaning	220
C.1.3	Data Coverage	221
C.1.4	Further Summary Statistics	223
C.2	Robustness	225
C.2.1	Monetary Surprises	225
C.2.2	Stock Prices	226
C.2.3	Credit Spreads	234
C.2.4	Debt	241
C.2.5	Investment	247
C.2.6	Mutual Funds	253
C.2.7	Syndicated Loans	257
C.3	Model	261
C.3.1	General Set-Up	261
C.3.2	Green Preferences	261
C.3.3	Pricing Climate Risk	262
C.3.4	Maximisation	262
C.3.5	Brown Premium: Risk and Preferences	263
C.3.6	Sustainable Investing and Monetary Policy	264

List of Figures

1.1	Global Cross-Border Lending to Russia by Currency	4
1.2	Debt Profile and Currency Composition of Russian Firms by Sanctioning Status.	30
1.3	Global banks' total lending to Russia.	37
1.4	Currency composition of lending to non-residents.	38
1.5	Margins Decomposition of Total Lending to Russia in USD and EUR	41
1.6	Bank Claims on Russia after the 2014 Sectoral Sanctions: Dynamic Effects	50
1.7	Jurisdiction and Russia-Exposure Spillovers to Total Claims	54
1.8	De-Dollarisation Spillovers by Jurisdiction and Russia Exposure . .	55
1.9	Russian Syndicated Loans Size and Spread by Bank Jurisdiction Before and After 2014.	60
1.10	Russian Syndicated Loans Size and Spread by Currency Before and After 2014.	61
1.11	U.S. Coalition Controlled Claims - Nationality Basis.	72
1.12	Difference between Nationality and Residence-basis Share of Controlled Claims.	73
2.1	Currency shares of UK non-EU exports.	79
2.2	Currency share of UK non-EU imports.	85
2.3	Revisions to 1-year ahead forecast of the GBP/USD exchange rate and realised spot monthly changes of GBP/USD.	88
2.4	Quarterly averages across firms of text-analysis indices based on earnings calls of listed UK companies.	91
2.5	Firm level currency mismatches and reduction in GBP invoicing. . .	93

2.6	Exchange rate gains/losses from firms' currency mismatches.	94
2.7	Event study: effect of currency mismatch-weighted GBP depreci- ation on GBP invoicing	101
2.8	Currency mismatch channel: contribution to aggregate shift in GBP	103
2.9	GBP invoicing by GBP exposure and market power	104
2.10	Event study: effect of market power at the margin with high expos- ure to GBP depreciation.	107
2.11	Dynamic elasticity of export quantities to appreciation of USD. . .	110
3.1	Monetary policy surprises on Fed announcement dates	127
3.2	Response of non-US stock prices to US monetary policy: Scope 1 emission intensity	140
3.3	Response of non-US credit spreads to US monetary policy: Scope 1 emission intensity	142
3.4	Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity	144
3.5	Response of non-US firm-level investment to a 25 basis point exo- genous tightening by the Fed: Scope 1 emission intensity	145
3.6	Response of country-level investment to a 25 basis point exogenous tightening by the Fed: Scope 1 emission intensity	146
3.7	The Model at a Glance	148
3.8	Empirical Strategy	153
3.9	Response of non-US holdings to US monetary policy: Scope 1 emission	156
3.10	Response of non-US holdings of ESG funds to US monetary policy: Scope 1 emission	157
A.1	Global Cross-Border Claims to Russia by Residence.	164
A.2	Global Cross-Border Claims to BICS by Residence.	164
A.3	Debt Profile of Russian non-Operating Companies under Sectoral Sanctions.	166
A.4	Coalition composition of lending to non-residents.	173

A.5	UK-resident global banks' total lending to and deposits from Russia.	174
A.6	Currency composition of lending to non-residents. Lending growth winsorised to be $[-100\%, 100\%]$.	175
A.7	UK-resident global banks' total deposits from Russia.	176
A.8	Currency composition of deposits from non-residents.	176
A.9	Currency composition of deposits from non-residents. (Only banks lending to Russia)	177
A.10	Margins decomposition: Total lending to Russia in GBP and "Other" Currencies	178
A.11	Margins decomposition: Total lending to all countries other than Russia.	178
A.12	Russian Syndicated Loans Size Spread In Ruble Before and After 2014.	190
A.13	U.S. Coalition Controlled Claims - Residence Basis.	194
B.1	Intensive/extensive margin decomposition of GBP invoicing shift.	197
B.2	Net exposure to USD (in % of gross trade) by trade size distribution.	199
B.3	Correlates of the invoicing shift.	200
B.4	Currency share of UK non-EU non-US exports.	201
B.5	Distribution market shares.	202
B.6	Distribution top shares.	203
B.7	Shocks GIV.	204
B.8	Event study USD	209
B.9	Event study EUR	210
B.10	Event study GBP - quarterly	210
B.11	Event study USD - quarterly	211
B.12	Event study EUR - quarterly	211
B.13	Event study with exposure in GBP and exports only	212
B.14	Event study with exposure in GBP and imports only	212
B.15	Event study with exposure in USD and exports only	213
B.16	Event study with exposure in USD and imports only	213

B.17 Event study with exposure in EUR and exports only	214
B.18 Event study with exposure in EUR and imports only	214
B.19 Hedging channel: contribution to aggregate shift in GBP	215
B.20 Dynamic response of export value to appreciation of USD granular exchange rate.	216
B.21 Dynamic elasticity of export quantities to appreciation of USD. . .	217
C.1 Density Distribution of Carbon Intensity	224
C.2 Density Distribution of Log of Carbon Intensity	224
C.3 Monetary policy surprises on Fed announcement dates: Median rotation series	225
C.4 Response of non-US stock prices to US monetary policy: Average effect	226
C.5 Response of non-US stock prices to US monetary policy: Average effect - Advanced Economies only	227
C.6 Response of non-US stock prices to US monetary policy (“Median Rotation” shocks): Scope 1 emission intensity	227
C.7 Response of non-US stock prices to US monetary policy: Scope 2 emission intensity	228
C.8 Response of non-US stock prices to US monetary policy: Scope 1 absolute emissions	228
C.9 Response of non-US stock prices to US monetary policy: Scope 1 emission intensity (reporting only)	229
C.10 Response of non-US stock prices to US monetary policy: Scope 1 emission intensity (Advanced Economies)	229
C.11 Response of non-US stock prices to US monetary policy: Scope 1 emission intensity (Emerging Market Economies)	230
C.12 Response of non-US stock prices to US monetary policy: Scope 1 emission intensity checking pre-trend	230
C.13 Response of non-US stock prices to US monetary policy: emission quintiles (Scope 1)	231

C.14 Response of non-US stock prices to US monetary policy: Scope 1 emission intensity with positive shocks only	231
C.15 Response of non-US stock prices to US monetary policy: Scope 1 emission intensity with negative shocks only	232
C.16 Response of non-US stock prices to US monetary policy: Scope 1 emission intensity with dividends per share as control	232
C.17 Response of non-US stock prices to US monetary policy: Scope 1 emission intensity with energy sector	233
C.18 Response of non-US stock prices to US monetary policy: Scope 1 emission intensity excluding double-listing in US and American Depository Receipts	233
C.19 Response of non-US bond spreads to US monetary policy: Average effect	234
C.20 Response of non-US bond spreads to US monetary policy: Average effect - Advanced Economies only	235
C.21 Response of non-US bond spreads to US monetary policy (“Median Rotation” shocks): Scope 1 emission intensity	235
C.22 Response of non-US bond spreads to US monetary policy: Scope 2 emission intensity	236
C.23 Response of non-US bond spreads to US monetary policy: Scope 1 absolute emissions	236
C.24 Response of non-US bond spreads to US monetary policy: Scope 1 emission intensity (reporting only)	237
C.25 Response of non-US bond spreads to US monetary policy: Scope 1 emission intensity (Advanced Economies)	237
C.26 Response of non-US bond spreads to US monetary policy: Scope 1 emission intensity (Emerging Market Economies)	238
C.27 Response of non-US bond spreads to US monetary policy: Scope 1 emission intensity checking pre-trend	238

C.28 Response of non-US bond spreads to US monetary policy: emission quintiles (Scope 1)	239
C.29 Response of non-US bond spreads to US monetary policy: Scope 1 emission intensity with positive shocks only	239
C.30 Response of non-US bond spreads to US monetary policy: Scope 1 emission intensity with negative shocks only	240
C.31 Response of non-US firm-level debt to US monetary policy: average	241
C.32 Response of non-US firm-level debt to US monetary policy (“Median Rotation” shocks): Scope 1 emission intensity	242
C.33 Response of non-US firm-level debt to US monetary policy: Scope 2 emission intensity	242
C.34 Response of non-US firm-level debt to US monetary policy: Scope 1 absolute emissions	243
C.35 Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity (reporting only)	243
C.36 Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity (Advanced Economies)	244
C.37 Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity (Emerging Market Economies)	244
C.38 Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity checking pre-trend	245
C.39 Response of non-US firm-level debt to US monetary policy: emission quintiles (Scope 1)	245
C.40 Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity with positive shocks only	246
C.41 Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity with negative shocks only	246
C.42 Response of non-US firm-level investment to US monetary policy: average	247

C.43 Response of non-US firm-level investment to US monetary policy	
(“Median Rotation” shocks): Scope 1 emission intensity	248
C.44 Response of non-US firm-level investment to US monetary policy:	
Scope 2 emission intensity	248
C.45 Response of non-US firm-level investment to US monetary policy:	
Scope 1 absolute emissions	249
C.46 Response of non-US firm-level investment to US monetary policy:	
Scope 1 emission intensity (reporting only)	249
C.47 Response of non-US firm-level investment to US monetary policy:	
Scope 1 emission intensity (Advanced Economies)	250
C.48 Response of non-US firm-level investment to US monetary policy:	
Scope 1 emission intensity (Emerging Market Economies)	250
C.49 Response of non-US firm-level investment to US monetary policy:	
Scope 1 emission intensity checking pre-trend	251
C.50 Response of non-US firm-level investment to US monetary policy:	
emission quintiles (Scope 1)	251
C.51 Response of non-US firm-level investment to US monetary policy:	
Scope 1 emission intensity with positive shocks only	252
C.52 Response of non-US firm-level investment to US monetary policy:	
Scope 1 emission intensity with negative shocks only	252
C.53 Response of shares to US monetary policy: Average - ESG only . .	253
C.54 Response of shares to US monetary policy: Average - ESG and Non-	
ESG	253

List of Tables

1.1	Firm-Level Debt and Leverage	32
1.2	Interest Expenses and Debt Burden	33
1.3	Bank Claims on Russia after the 2014 Sectoral Sanctions: Jurisdictional and Currency Margins	46
1.4	Bank Claims on Russia Relative to Other Destinations after the 2014 Sectoral Sanctions: Jurisdictional and Currency Margins	47
1.5	Lender-Jurisdiction and Vehicle-Currency Substitution	69
2.1	Results from baseline specification.	99
2.2	Relevance of market power.	106
3.1	Summary statistics of main firm-level covariates	132
A.1	EU-U.S. 2014 Sectoral Sanctions Lists	165
A.2	Currency Debt Levels	167
A.3	Firm-Level Debt and Leverage (All Firms)	168
A.4	Interest Expenses and Debt Burden (All Firms)	169
A.5	Currency Debt Levels (All Firms / Broad Sample)	170
A.6	Currency Debt Shares	171
A.7	Currency Debt Shares (All Firms / Broad Sample)	172
A.8	Bank Claims on Russia after the 2014 Sectoral Sanctions: Currency-Margin Fixed-Effect Variants	179
A.9	Bank Claims on Russia after the 2014 Sectoral Sanctions: Split by Currency	180
A.10	Bank Claims on Russia Relative to Other Destinations after the 2014 Sectoral Sanctions: Currency-Margin Fixed-Effect Variants	181

A.11 Bank Claims on Russia Relative to Other Destinations after the 2014	
Sectoral Sanctions: Split by Currency	182
A.12 Geopolitical Distance Quartiles for Selected Countries	183
A.13 Spillovers to Non-Russia Destinations: Total Claims, Coalition Banks	184
A.14 Spillovers to Non-Russia Destinations: Total Claims, Russia-exposed	
Banks	185
A.15 Spillovers to Non-Russia Destinations: Total Claims, Coalition ×	
Russia-exposed Banks	186
A.16 Spillovers to Non-Russia Destinations: Currency Margin, Coalition	
Banks	187
A.17 Spillovers to Non-Russia Destinations: Currency Margin, Russia-	
exposed Banks	188
A.18 Spillovers to Non-Russia Destinations: Currency Margin, Coalition	
× Russia-exposed Banks	189
A.19 Fixed-Effects Progression for Lender-Jurisdiction and Vehicle-Currency	
Substitution	191
A.20 Vehicle-Currency Substitution: Full Coefficients and Contract Controls	192
A.21 Lender-Jurisdiction and Vehicle-Currency Substitution: Within Borrower-	
Lender	193
B.1 Summary statistics (Count).	196
B.2 Baseline with controls spelt out.	206
B.3 Baseline up to 2022	207
B.4 Baseline with quantity share instead of value share.	208
C.1 Country coverage of final sample	221
C.2 Sector coverage of final sample	222
C.3 Summary statistics of main firm-level covariates - Scope 2	223
C.4 Mutual Fund International Flows - Average response to US monetary	
policy	255

C.5	Mutual Fund International Flows - Interaction ESG mandate & US monetary policy	256
C.6	Syndicated Loans: Lenders' Commitment, Non-US Borrowers' Emis- sions & US monetary policy	260

1

Sanctions and Currencies in Global Credit

with Giovanni Rosso and Roger Vicqu ry

This paper studies how financial sanctions affect the allocation of cross-border credit, the dominance of the U.S. dollar in global credit markets and, ultimately, the oversight of hegemonic powers over global financial intermediation. We focus on a unique laboratory: the 2014 EU-U.S. sectoral sanctions against Russia. We document how, despite the absence of currency-specific restrictions, the U.S. dollar share of global banking claims on Russia fell from 65 percent to 25 percent between 2014 and 2021, while the euro share rose from 20 percent to 45 percent. Combining firm, bank, and loan-level data, we show that this de-dollarisation reflected currency-specific de-risking by global banks, arising from higher sanction-compliance costs in the dollar payment system. Our analysis proceeds in three steps. First, we show that euro-denominated claims rose entirely among non-sanctioned Russian firms, ruling out sanction avoidance as an explanation for the euro shift. Second, confidential data on the universe of cross-border claims of UK-resident banks allow us to disentangle jurisdictional and currency-specific de-risking. Banks

We are grateful for valuable comments and encouragement to Saleem Bahaj, Valentina Bruno, Matteo Cacciato, Christopher Clayton, Ambrogio Cesa-Bianchi, Giancarlo Corsetti, Ricardo Correa, Barry Eichengreen, Andrea Ferrero, Simon Lloyd, Matteo Maggiori, Alberto Martin, Friederike Niepmann, Daniel Ostry, Marco Pinchetti, Dennis Reinhardt, Ricardo Reis, Jesse Schreger, Neeltje Van Horen, and to our discussants Paul Bouscasse, Konstantin Egorov, Galina Hale, Peter John Lambert, Yang Liu, Valerio Nispi Landi, Goetz von Peter, and Oliver Xie. We would also like to thank for helpful discussions the participants to the RFS-GCAP-GSB Conference on *The Geoeconomics of Financial Markets* at Stanford GSB, the 2026 IFS Annual Conference, the 2026 CEPR-ESSIM Symposium, the Kiel-CEPR Research Seminar in International Economics, the 2026 Bank of England BEAR Conference, the 18th FIW-Research Conference on International Economics, the Workshop on Geopolitical Tensions and Global Capital Flows at University of Groningen, the 2025 Joint BdF-EUI Pierre Werner Chair Conference, the 9th Annual Research Conference of the National Bank of Ukraine, the 2025 Transatlantic Doctoral Conference at LBS, and seminars at Oxford University and Maastricht University. We thank John Lowes and Swapn Kumar Pradhan for assistance and advice regarding the UK and BIS banking data. All errors and omissions remain our own. The views expressed in this paper are those of the authors and not necessarily those of the Bank of England and its committees.

with ultimate parents in sanctioning jurisdictions reduced claims on Russia by 50 percent relative to other banks. However, all banks—regardless of ultimate-parent jurisdiction—increased non-dollar, and particularly euro, claims relative to dollar claims by up to 400 percent. Third, we turn to prices and quantities in the Russian syndicated-loan market. After 2014, dollar loans to Russian borrowers carried a settlement-risk premium of about 50 basis points relative to comparable euro loans. Together with a large positive shift in euro loan volumes, this points to high substitutability between vehicle currencies in global credit. Finally, we provide a capital-flows perspective on geoeconomic power. We show that U.S. coalition control over Russian claims rested mainly on the use of the dollar by non-U.S. banks before 2014 and fell substantially thereafter. Our results show how the coercive use of a hegemonic currency can redirect private intermediation toward alternative vehicle currencies, thereby endogenously weakening hegemonic financial power.

JEL Classification: E42, E65, F34, F51, G21

1.1 Introduction

In a 2016 speech taking stock of the new U.S. approach to economic and financial sanctions under the Obama administration, then-Treasury Secretary Jacob Lew cautioned that while “economic sanctions have become a powerful force in service of clear and coordinated foreign policy objectives,” their “overuse (. . .) could threaten the central role of the U.S. financial system globally, not to mention the effectiveness of our sanctions in the future.”¹ In recent years, this concern has resurfaced among U.S. policymakers,² prominent scholars and market participants,³ and even the President of the United States.⁴

The tension underlying these debates has since been formalised in a growing literature on geoeconomics. Clayton, Maggiori et al. (2025a) describe how economic

¹See The Evolution of Sanctions and Lessons for the Future, Remarks at the Carnegie Endowment for International Peace by U.S. Treasury Secretary Jacob Lew, March 30, 2016. Fishman (2025) provides an insightful discussion of internal debates within the U.S. Treasury on these issues during the Obama administration.

²*Yellen Says Sanctions May Risk Hegemony of U.S. Dollar*, Barron’s, April 16, 2023; *Russia Sanctions Threaten to Erode Dominance of U.S. Dollar, Says IMF*, Financial Times, March 31, 2022.

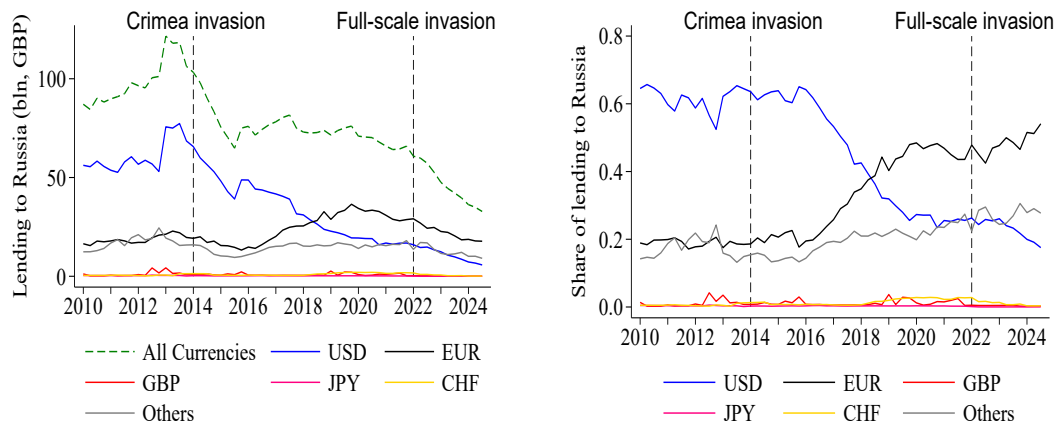
³James et al. (2022), Eichengreen (2022b), Dooley et al. (2022) and Frankel (2023).

⁴*Remarks at the Economic Club of New York by President Donald J. Trump*, September 5, 2024.

sanctions have become a central instrument of U.S. geoeconomic power—defined as the ability of a hegemonic state to leverage control over strategic sectors to enforce compliance abroad. Clayton, Maggiori et al. (2025b) argue that U.S. geoeconomic power stems primarily from its dominance in financial services and highlight a fundamental trade-off: the use of geoeconomic power by an hegemon encourages the adoption of anti-coercion policies, reducing their dependence on the hegemon.

In this paper, we empirically study how uncertainty about future coercive actions by the hegemonic power shapes the allocation of cross-border credit, the use of vehicle currencies in global financial markets and, ultimately, the degree of oversight that the hegemon can maintain over global financial intermediation. We leverage a unique institutional setting created by a policy shock: the 2014 Western *sectoral* financial sanctions imposed on Russia. In the aftermath of the 2014 invasion of Crimea, the EU and the U.S., alongside other Western countries, restricted the ability of a select group of large Russian firms, mainly in the energy and financial sectors, to access *new* credit from Western banks. Crucially, these 2014 sectoral sanctions, which remained in place until the full-scale invasion of Ukraine in 2022, stopped short of generalised stricter measures such as asset freezes or full blocking, and continued to allow cross-border lending to the vast majority of Russian firms. This episode provides an ideal setting to examine how uncertainty over future sanctions and sanction compliance risk affect the supply of international credit and its currency composition, as global banks and borrowers adapted their behaviour to limit exposure to potential coercive actions.

As shown in Figure 1.1, global cross-border lending to Russia fell sharply following the 2014 sectoral sanctions. Yet a striking pattern emerges in its currency composition. Although the sanctions were largely symmetrical between the EU and the U.S. and contained no currency-specific provisions, dollar-denominated lending to Russia declined more than three-fold between 2014 and 2021, while lending in euros increased over the same period. Specifically, the share of cross-border claims on Russia denominated in euros, as reported by the BIS, rose from about 20 percent



(a) Total lending and currency breakdown (b) Shares of lending by currency

Figure 1.1: Global Cross-Border Lending to Russia by Currency

Note. – Amount outstanding of total cross-border claims including all counterparty sectors, all currency types of reporting country, all types of instruments, all parent countries, all reporting institutions and countries. Lending converted from USD into GBP using quarterly averages of spot FX reported by the Bank of England. Proportion of each currency group out of total lending to Russia is in simple shares from 0 to 1.

Source: BIS locational banking dataset.

before 2014 to roughly 45 percent by 2022, whereas the share of U.S.-dollar claims fell from around 65 percent to 25 percent.

What drove this shift from dollars to euros in the denomination of credit flows? We argue that sectoral sanctions imposed by a coalition of states, combined with a hegemon’s extra-territorial oversight over the use of its currency, generate two distinct frictions: a jurisdictional friction and a currency-specific friction.

On the one hand, banks headquartered in sanctioning jurisdictions face higher expected compliance costs when transacting with firms or jurisdictions already subject to partial sanctions, where uncertainty about the ultimate beneficiary or future sanction status is material. They therefore reduce exposures more than banks based elsewhere, consistent with classical compliance de-risking.

On the other hand, the U.S. exercises extra-territorial jurisdiction over dollar-clearing under a strict-liability regime for USD correspondent banks. When transactions involve counterparties whose compliance status cannot be verified with sufficient confidence, USD correspondent banks face non-trivial legal and financial

exposure, and may become reluctant to process such payments, severing relationships (Matvos and Neiman, 2026). This can create settlement risk on dollar-denominated claims, as payments may not be executed if compliance risk cannot be absorbed by correspondent banks. This mechanism induces currency-specific de-risking by all banks, including those outside sanctioning jurisdictions.

Our analysis proceeds in three main steps, leveraging firm-, bank- and loan-level data. First, we rely on Capital IQ firm-level balance sheet data, covering a large sample of Russian firms, to show that the increase in euro claims was unambiguously driven by non-sanctioned Russian firms. This rules out sanction-avoidance motives for euro-denomination of Russian claims as a meaningful contributor to the aggregate patterns motivating our study. We also show that, although all firms, regardless of their sanctioning status, reduced their debt levels, firms under sectoral sanctions experienced a stark deterioration of their debt burden, driven by higher interest payments.

Second, we disentangle the effect of jurisdiction and currency-specific frictions in the evolution of global claims on Russia after the 2014 sectoral sanctions. We rely on a confidential administrative dataset covering the universe of cross-border claims of UK-resident banks, including foreign branches and subsidiaries, broken down by currency of denomination. We begin by providing a detailed decomposition of UK-residents claims on Russia, showing that their euro-isation was driven by banks previously lending to Russia in U.S. dollars from both sanctioning and non-sanctioning jurisdictions. We then quantify empirically that banks whose ultimate parent was based in a sanctioning jurisdiction reduced total claims on Russia by about 50% relative to banks ultimately based in a non-sanctioning jurisdiction, across all currencies. Relative to their claims on all other destinations, the corresponding decline in total claims on Russia is about 35%. However, all banks, regardless of their ultimate parent’s nationality, de-dollarised the currency denomination of their Russian claims. Relative to claims in U.S. dollars, claims in all non-USD currencies increased by about a factor of 2.4 to 4, while euro-denominated claims increased by about a factor of 3.5 to 7.5. These shifts are

positive for banks in both sanctioning and non-sanctioning jurisdictions. They are numerically larger for banks ultimately based in non-sanctioning jurisdictions, but the difference between the two groups is not statistically significant. Furthermore, we provide evidence of de-dollarisation spillovers driven by banks exposed to Russian sectoral sanctions. We show that banks with Russian claims in the quarter before the invasion of Crimea, especially those whose ultimate parent was based in a sanctioning jurisdiction, denominated more of their non-Russia claims in euro relative to U.S. dollars. This spillover is concentrated in destinations less aligned with the West, while we find little systematic evidence that these banks reduced overall claims to non-Russia destinations.

Third, we assess how prices and quantities of syndicated loans to Russian non-sanctioned firms reacted to these same jurisdiction and currency frictions following the 2014 sectoral sanctions. We rely on Dealscan loan-level data for the universe of syndicated loans to emerging markets to disentangle quantity and price responses. We find strong evidence of a settlement-risk premium on U.S. dollar loans to Russian borrowers, relative to the euro: in our preferred specification, within the same borrower dollar loans are priced about 55 bps higher than comparable euro loans, equivalent to a 19 percent decline in relative euro-dollar pricing. The same exercise reveals that syndicated lending volumes in euro increased by about 95%, relative to dollars. Combining these quantity and price responses implies a reduced-form EUR-USD substitution elasticity of about 3 to 5, suggesting substantial substitutability between vehicle currencies in global credit markets. Looking at jurisdiction-specific shifts, we find evidence in favour of a relative de-risking of sanctioning coalition banks on the extensive margin only, with no differential behaviour in loan pricing for coalition and non-coalition banks. This suggests a quantity adjustment of sanctioning coalition banks severing relationships with higher compliance-risk borrowers.

Finally, we connect our findings with the growing literature on geoeconomic power and the drivers of global economic fragmentation. We provide a capital flows-based measurement of hegemon-controlled financial inputs, relying on BIS

data on global banking flows by currency, both on a residence and a nationality basis. We show that this approach is a relevant complement to measures relying on financial services trade data. It notably allows to disentangle three sources of hegemonic control over financial intermediation, derived from the empirical findings in our paper: i) the hegemon’s oversight on its own banks, ii) its indirect oversight over banks from allied countries, and iii) its oversight on the use of the global hegemonic currency. We apply this framework, which is easily extendable to all countries covered by BIS data, to the Russian case-study. According to our measure, most of the U.S. coalition control over claims on Russia before 2014 came from the use of the U.S. dollar by non-American banks. The share of claims on Russia controlled by the American coalition then declined substantially after 2014, from close to 100% to about 74% at the end of 2021. Importantly, the decline in claims controlled via dollar usage was partially offset by an increase in the share of claims by banks under coalition jurisdiction in other currencies.

We now turn to a review of the related literature. Then the paper is organised as follows. Section 1.2 summarises the financial sanctions enacted by the U.S. and the EU between 2014 and 2021, and highlights the currency-specific sanction compliance costs embedded by U.S. oversight on correspondent banks and the U.S. dollar payment system. Section 1.3 describes our data. Section 1.4 provides firm-level evidence on the debt profile and currency composition of Russian firms under sectoral sanctions. Sections 1.5 and 1.6 empirically assess the relevance of jurisdiction and currency-specific frictions introduced by the 2014 sectoral sanctions by leveraging, respectively, a confidential bank-level panel covering the claims of UK resident global banks by currency, and the universe of syndicated loans to emerging markets. Section 1.7 discusses our results in the context of the literature on geoeconomics and the measurement and dynamics of geoeconomic power. Section 1.8 concludes.

Related Literature

Our paper relates to a growing literature studying the effect of economic and financial sanctions, the interplay between geopolitics, global capital flows, the international monetary system and, finally, the use of coercive economic measures by global hegemonic powers.

Economics of Sanctions There has been a growing interest in the effect of sanctions as a central tool in international relations, particularly looking at the successive sanctioning regimes against Russia since 2014 (Ahn and Ludema, 2020; Gehring, 2022; Crozet and Hinz, 2020; Besedeš et al., 2021; Corsetti, Demir et al., 2024; Egorov et al., 2025). Focusing on financial sanctions, a large body of literature has studied their effect on macroeconomic dynamics and financial markets (Ghironi et al., 2023; Itskhoki and Mukhin, 2023; Lorenzoni and Werning, 2023; Eichengreen, Ferrari Minesso et al., 2024; Minesso et al., 2025; Bianchi and Sosa-Padilla, 2024). In contrast, our paper focuses on how the *risk* of coercive actions influences the allocation of international capital flows and the use of vehicle currencies in international finance, leveraging several granular datasets.

Closely related to our paper is the work of Efung et al. (2023), who study the effect of financial sanctions on the cross-border supply of credit by German banks and their foreign affiliates, relying on a granular administrative dataset on German banks' cross-border claims. Similarly to our paper, they study sanctions-induced de-risking of international financial activities, focusing on the role of German banks' subsidiaries in jurisdictions with weaker compliance enforcement. Our paper uniquely considers the currency dimension of sanction-compliance risk by systematically studying the currency composition of firms balance-sheets, bank cross-border claims and syndicated loans. Furthermore, by leveraging a granular administrative dataset covering the universe of London-based banks, we are able to disentangle sanctions-induced shifts for banks across both sanctioning and non-sanctioning jurisdictions, on an ultimate-parent basis.

In another closely related contribution, Matvos and Neiman (2026) study how financial sanctions affect banks' access to the global payments network. They show that sanctions sever correspondent banking relationships, and hence the ability to directly access clearing in major currencies and, particularly, the U.S. dollar, while inducing a reconfiguration of payment networks towards alternative arrangements. Although they study the effect of post-2022 financial sanctions on Russia, the payment system frictions they describe are precisely the mechanism underlying relative currency shift and de-dollarisation of claims on Russia in our paper: the key role of correspondent banks in dollar clearing is what embeds a U.S. government global jurisdiction on dollar transactions, including credit flows, and therefore implies higher sanction compliance risk in dollar vs. non-U.S. dollar currencies in high-geopolitical risk jurisdictions.

In other related work, Keerati (2022) studies the differential impact of the 2014 financial sanctions on sanctioned and non-sanctioned Russian firms, with some overlap in the datasets we employ.⁵ Similarly, Mamonov et al. (2022) study the consequences, and anticipation effects, of the 2014 financial sanctions on the balance-sheets of Russian sanctioned and non-sanctioned banks. In Section 1.4 we also analyse Russian firm-level data and at the differential evolution of sanctioned and non-sanctioned Russian firms after the 2014 invasion of Crimea. However, we chiefly focus on debt-levels and, uniquely, relative to the existing literature, the currency composition of Russian firms' liabilities. Furthermore, although the firm-level analysis is informative for the interpretation of our broader empirical evidence, the focus of this paper is chiefly on vehicle currency choice and allocation of credit by *global* banks to *non-sanctioned* Russian firms.

The effect of sanctions on the use of the dollar as a vehicle currency has already received some empirical attention in an international trade context, focusing on the invoicing currency of goods trade. Berthou (2023) provides evidence of de-dollarisation of French trade with Russia after the 2014 invasion of Crimea, looking

⁵We also rely on DealScan data to observe Russian and emerging-markets syndicated loans, although we look at a different firm-level balance-sheet dataset, Capital IQ, that allows us to observe the currency composition of the capital structure.

at French granular customs data. In parallel work, Chupilkin et al. (2023) rely on Russian customs data and focus on the de-dollarisation effect on trade invoicing of the 2022 sanctions, following the full-scale invasion of Ukraine. From a theoretical perspective, Bianchi and Sosa-Padilla (2024) study how international financial sanctions can reduce the convenience yield on dollar assets. Our paper is, to our knowledge, the first study of the effect of sanction *risk* on the use of vehicle currencies in financial flows, relying on bank-level and loan-level data from a global, nationality-basis, perspective.

More broadly, our paper relates to the literature on the determinants of currency choice in international finance (G. B. Hale et al., 2020; Maggiori et al., 2020; Maggiori et al., 2019; Clayton, Dos Santos et al., 2024; Lewis and Xie, 2025). We show that sanction-compliance risk can itself be an important determinant of currency denomination, inducing substitution away from the U.S. dollar and towards alternative vehicle currencies.

Geoeconomics, Capital Flows and the International Monetary System

Our work also speaks to a growing literature studying the interplay between geopolitical risk and changing patterns in international capital flows and the international monetary system (Reinhardt et al., 2025; Arvai, Coimbra and Pinchetti, 2026; Emter et al., 2026; Eichengreen, Mehl et al., 2019; Koosakul et al., 2024; McDowell, 2023; Arslanalp et al., 2022; Vicquéry, 2022; Pflueger and Yared, 2024; Goldberg and Hannaoui, 2024; Niepmann and Shen, 2025; De Haas et al., 2025) as well as the, so far under-appreciated role, of cross-border payment systems (Ferrari Minesso, Mehl et al., 2025; Cipriani et al., 2023; Eichengreen, 2022a). Our work also directly contributes to a growing literature on geoeconomics, studying the strategic use by hegemonic powers of the economic strength they derive from financial and trade relationships (Broner et al., 2025; Mayer et al., 2025; Liu and Yang, 2025; Clayton, Maggiori et al., 2025b; Clayton, Coppola et al., 2025b; Clayton, Maggiori et al., 2025a; Clayton, Coppola et al., 2025a). Closely related to the questions we analyse, Clayton, Maggiori et al. (2025a) quantify the sources of US geoeconomic power,

showing it mostly relies on dominance in financial services, and the US dollar payment system in particular. They also provide a framework to think about anti-coercion strategies and their general equilibrium implications in terms of economic fragmentation. Our paper is, to our knowledge, the first attempt to empirically relate an erosion of dollar dominance in international financial flows to the oversight exerted by the U.S. on the dollar payment system, and the global extra-territorial compliance-risk it implies. We focus on an ideal setting in this respect, the 2014-2021 sectoral sanctions on Russia, where the U.S. and the EU imposed lending restrictions only on a sub-set of Russian borrowers in global credit markets. This allows us to precisely analyse *risk* of future coercive actions and its implications in terms of global economic fragmentation. We show that financial sanctions operate by introducing both jurisdiction and currency specific frictions, via the dollar payment system. We bring these empirical insights to the macro literature on geo-economic power by proposing a capital-flows based measurement of the share of inputs controlled by the hegemonic power, derived from our empirical analysis.

1.2 Jurisdiction and Currency Frictions in the 2014 Financial Sanctions on Russia

Why did cross-border financial flows to Russia after 2014 shift away from the U.S. dollar and increasingly relied on the euro? A natural explanation would be differences in the scope of Western sanctions. Yet, the sanctioning measures adopted by the United States, the European Union, and their partners were aligned, targeting the access to Western capital markets for a sub-set of large systemic Russian firms. There was no direct provision targeting currency usage in the 2014 sectoral sanctions. We argue that the key asymmetry susceptible to explain a shift towards euro denomination of Russian claims lies in how the extra-territorial application of U.S. sanctions interacts with the structure of the global USD payment network.

The 2014 sectoral sanctions thus introduced two distinct frictions in cross-border flows to Russia. First, a jurisdiction-specific friction that affects banks under the oversight of a sanctioning jurisdiction and is in principle symmetric across Western jurisdictions. Second, a currency-specific friction, arising from the *extra-territorial* application of U.S. sanctions to any transaction clearing via the dollar payment system. This asymmetry creates higher sanction-compliance costs and, consequently, settlement risk in U.S. dollars relative to other currencies and, in particular, the euro.

1.2.1 Jurisdiction-specific Frictions

Sectoral Sanctions

The immediate sanction response to Russia’s annexation of Crimea in 2014 first involved a set of “individual” restrictive measures targeting politically connected persons and entities. Inclusion on the Specially Designated Nationals (SDN) list entails a prohibition for all U.S. persons to engage in any transaction or provide any funds, goods, or services to the designated party, effectively excluding it from the U.S. financial system, as well as a comprehensive asset freeze⁶.

⁶The EU applies substantively equivalent measures through its consolidated list of designated persons and entities subject to asset freezes and prohibitions on making funds or economic resources available.

Fishman (2025) describes how, over the course of 2014, parts of the U.S. administration were in favour of adopting such comprehensive blocking measures against Russia’s strategic sectors. This would have been in line with the approach taken against Iran, which ultimately paved the way to the 2015 Joint Comprehensive Plan of Action (JCPOA), also known as the “Iran Deal”, limiting the country’s nuclear programme in exchange for sanctions relief. In the Russian case, however, the U.S. Treasury viewed a wide-scale blocking of large Russian state-owned enterprises as presenting substantial financial stability risks, given their size and level of integration within the global financial system.

Instead, so-called “sectoral”, more targeted, financial sanctions were deployed by both the U.S. and the EU in the aftermath of the invasion of Crimea⁷. These measures were deliberately narrower in scope: rather than blocking access to all financial services and freezing assets, they restricted the ability of a sub-set of systemically important Russian firms to access *new* financing and therefore to refinance their existing foreign liabilities.

Significant diplomatic efforts took place during the summer of 2014 to reach a EU-U.S. agreement on the implementation of sectoral sanctions against Russia, and to align the two sanctioning regimes in the second half of 2014.

Sanction Alignment in Western Jurisdictions

In the United States, sectoral sanctions were introduced under *Executive Order 13662* of March 20 2014⁸. The first designations, announced on July 16 2014, prohibited U.S. persons from providing new financing - defined as new debt of longer than 90 days’ maturity or new equity - to a limited set of large Russian firms in the financial, energy, and defence sectors. These restrictions did not entail

⁷Trade sectoral sanctions, targeting military and dual-use goods and deepwater, Arctic offshore, and shale oil exploration and production projects.

⁸Which authorised the Secretary of the Treasury to identify persons operating in specified sectors of the Russian economy and impose targeted financing restrictions through the “Sectoral Sanctions Identifications” (SSI) List. See U.S. Department of the Treasury, Office of Foreign Assets Control, *Executive Order 13662 of March 20 2014*, available at <https://www.govinfo.gov/link/cpd/executiveorder/13662>, with the end-2014 SSI List (“Changes to the SSI List in 2014”) available at <https://www.treasury.gov/ofac/downloads/ssi/ssinew14.pdf>.

any asset freeze or wide-spread blocking of interactions with U.S. persons, and existing obligations could continue to be serviced.

In the European Union, a corresponding framework was adopted following the Foreign Affairs Council decision of July 22 2014⁹. The EU provisions prohibited EU persons from dealing in new transferable securities and money-market instruments beyond specified maturities, and from granting new loans or credit to the targeted entities. The EU’s sectoral measures therefore broadly matched, in EU law, the same banking, energy, and defence coverage as the U.S. sectoral sanctions, while likewise stopping short of imposing a full-fledged blocking or asset freezes on these firms.

By the end of 2014, the two regimes were essentially aligned on the same set of firms, as detailed in Table A.1. Only two differences persisted. First, the U.S. were the only jurisdiction to sanction Russian energy producer Novatek¹⁰. Second, the U.S. designated the Russian defense conglomerate Rostec, while the EU only specifically targeted its three main subsidiaries. Between 2014 and 2021, both regimes continued to target the same set of parent groups¹¹, with the maximum allowed short term financing maturity progressively brought down from the initial 90 days to 30 days in the EU and between 60 and 14 days, depending on the targeted sector, in the US¹².

The sanctioning coalition was broader than the U.S. and the EU. Financial centres in EEA-countries, including Norway and Iceland aligned themselves on

⁹Codified by Council Regulation (EU) No 833/2014 of 31 July 2014 concerning restrictive measures in view of Russia’s actions destabilising the situation in Ukraine, available at the end-2014 consolidated version at <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02014R0833-20141206>.

¹⁰The smallest operating firm under sectoral sanctions, as measured by outstanding principal debt in 2014 in Capital IQ data.

¹¹See Welt et al. (2022).

¹²Towards the end of our sample of interest, U.S. authorities broadened financial sanctions restrictions to include the primary market of Russian sovereign debt. A Directive under Executive Order 13883, effective 26 August 2019, prohibited U.S. banks from participating in the primary market for non-ruble-denominated bonds issued by the “Russian sovereign” and from lending non-ruble-denominated funds to it. In 2021, the restrictions was extended to ruble-denominated sovereign assets.

the EU sanctioning regime¹³. Similar, if not stricter, sanctioning regimes were put in place by Canada¹⁴ and Australia¹⁵ by early 2015. By end-2014, Japan and Switzerland had both aligned politically with EU and U.S. sanctions but implemented — at least *de jure* — narrower, capital-market-focused measures, restricting the issuance of long-term securities by five major Russian banks, with no explicit provision targeting new loans or energy and defence firms¹⁶. The set of sanctioning jurisdictions is therefore smaller than after the full-scale invasion of Ukraine in 2022, when the sanctioning coalition also included, among larger economies, New Zealand, Singapore, South Korea and Taiwan.

De-Risking and Implications for Lending to Unsanctioned Firms

Formally, these provisions did not prohibit financial institutions from maintaining pre-existing exposures to sanctioned entities or from extending credit to non-sanctioned Russian firms. Indeed, despite an immediate drop in outstanding claims in 2014-2015, a substantial volume of cross-border financing to Russia continued during this period, which is at the core of this paper’s empirical questions.

In practice, however, the broad anti-circumvention and ownership-control clauses embedded in both the U.S. and EU frameworks created significant compliance risk for banks. Complex ownership or control structures makes the identification of the ultimate beneficiary of a transaction uncertain, while the very logic of sanctions as a foreign-policy tool implies a risk that currently non-sanctioned counterparties in Russia could later be designated. This uncertainty explains a well-documented global trend in cross-border banking that has been dubbed

¹³After Brexit, the United Kingdom maintained regulatory continuity by adopting the *Russia (Sanctions) (EU Exit) Regulations 2019* under the *Sanctions and Anti-Money Laundering Act 2018*.

¹⁴Special Economic Measures (Russia) Regulations SOR/2014-58, available at: <https://laws.justice.gc.ca/eng/regulations/sor-2014-58/20150629/P1TT3xt3.html>

¹⁵Under Autonomous Sanctions (Designated Persons and Entities and Declared Persons – Russia and Ukraine), available at <https://www.dfat.gov.au/international-relations/security/sanctions/sanctions-regimes/russia-sanctions-framework>.

¹⁶For Switzerland, see Swiss Federal Council, “Situation in Ukraine: Federal Council decides on further measures,” 27 August 2014, <https://www.news.admin.ch/en/nsb?id=54221>. For Japan, see Ministry of Foreign Affairs of Japan, “Prohibitive Measure of Issue of Securities by Designated Russian Federation Banks and Their Subsidiaries,” 24 September 2014, https://www.mofa.go.jp/fp/nsp/page4e_000263.html.

regulatory “de-risking” (Bank for International Settlements, 2016; FSB, 2018) — the practice by financial institutions of curtailing or terminating relationships with certain clients or jurisdictions perceived as posing heightened compliance or reputational risks, rather than managing such risks through due diligence. Patterns of over-compliance by global financial institutions have been noted in legal analyses of sanction risk management (Verdier, 2023). Comparable mechanisms (e.g. a bank deciding to de-risk across all lending relationships in Russia) are likely to have been at play in our period of interest. As a result, sectoral sanctions likely generated an additional, indirect jurisdiction-specific friction for banks operating under sanctioning authorities, altering their incentive to extend credit to Russian unsanctioned firms beyond the directly prohibited activities. Additionally, de-risking and “voluntary alignment” by banks outside of sanctioning jurisdictions might also not be ruled out, and is ultimately an empirical question.

Proposition 1 *Cross-border lending to Russia should decline more for banks under sanctioning jurisdictions relative to banks from non-sanctioning jurisdictions, across all currencies of denomination.* This follows from the symmetric EU-U.S. sectoral financial sanctions introduced in 2014, which restricted new financing to a defined set of Russian firms and heightened compliance risks for transactions with any Russian counterparty and in any currency, thereby increasing the cost of providing credit for banks subject to these regimes.

1.2.2 Currency-specific Frictions

Dollar Settlement Risk under U.S. Extraterritoriality

Why then does a sanctioning regime, that is essentially symmetric across jurisdictions, generate asymmetric effects across currencies? We argue that a key explanation lies in EU-U.S. asymmetries in their approach to extra-territoriality and oversight of payment infrastructures. The interaction between U.S. extra-territorial jurisdiction and the structure of global payments networks gives rise to

currency-specific frictions, namely a form of *dollar-settlement risk* that does not arise in the euro system, which defines its jurisdiction more narrowly.

Under regulations of the Office of Foreign Assets Control (OFAC), the sanction-enforcement arm of the U.S. Treasury, any “U.S. person” is subject to U.S. sanctions¹⁷. Moreover, OFAC consistently interprets its jurisdiction to extend to any transaction with a so-called “U.S. nexus”, i.e. any connection that brings a foreign transaction within U.S. jurisdiction. A U.S. nexus arises when a U.S. person is involved directly, when U.S.-origin goods or services are used, or - in the case of financial flows - when a transaction is cleared or otherwise passes through the U.S. financial system.¹⁸

As noted by Cipriani et al. (2023), the vast majority of global U.S. dollar transactions are routed through New York, where settlement occurs on the *Fedwire Funds Service* or on *CHIPS*. Because only U.S.-regulated banks can participate directly in these systems, foreign banks must access them through correspondent accounts at U.S. institutions; as a result, nearly all cross-border dollar payments create a *U.S. nexus* and fall under U.S. jurisdiction. In a typical transaction, a foreign borrower or lender instructs its domestic bank to transfer funds in dollars, which are routed through the bank’s U.S. correspondent for final settlement on Fedwire or CHIPS, subjecting the payment to OFAC compliance screening¹⁹. Given the U.S. nexus embedded in any global USD payment transaction we should therefore expect sanctioned entities to be effectively cut off from the U.S. dollar circuit.

A natural question is whether such mechanisms might also affect transactions involving unsanctioned firms in at-risk jurisdictions, i.e. whether compliance de-risking disproportionately constrains transactions in U.S. dollars. Direct evidence

¹⁷A “*United States person*” comprises (i) any U.S. citizen or permanent resident wherever located, (ii) any entity organized under U.S. law, including its foreign branches, and (iii) any person physically present in the United States. See International Emergency Economic Powers Act (50 U.S.C. §§ 1701–1706); OFAC, “Who must comply with OFAC regulations?” FAQ 11.

¹⁸In such cases, the non-U.S. party is deemed to have “caused” a U.S. person, typically a correspondent bank in the United States, to process a payment subject to OFAC rules. See OFAC, *A Framework for OFAC Compliance Commitments* (2019); OFAC FAQ 16 (“When does a transaction have a U.S. nexus?”); and OFAC Enforcement Release: *Standard Chartered Bank* (Apr. 9, 2019).

¹⁹Payment instructions are transmitted via SWIFT, which provides standardized messaging but not settlement; the jurisdictional link arises in the settlement leg through the U.S. correspondent.

of this is provided by the public consultation carried out by the BIS Committee on Payments and Market Infrastructures, which reports that correspondent banks have become increasingly reluctant to provide services in currencies perceived as carrying high sanction compliance risk, i.e. the U.S dollar²⁰(Bank for International Settlements, 2016). Faced with uncertainty, U.S. correspondents operating under OFAC’s “strict liability” regime²¹ are indeed likely to adopt conservative compliance practices. They may delay or refuse transactions involving jurisdictions or sectors viewed as carrying elevated OFAC risk, particularly when ownership structures are opaque.

Consider, for example, a dollar-denominated loan from a Chinese bank to a Russian firm that is not itself sanctioned. Such an arrangement involves recurring cash flows — interest and principal payments — that must pass through a U.S. correspondent bank. Even if both parties remain fully compliant, the settlement of these payments depends on the correspondent’s evolving assessment of compliance risk. Should perceived exposure rise or risk tolerance narrow, payments may be prevented to settle, despite the liquidity and willingness to pay of the borrower. This constitutes a sanctions-compliance-driven form of settlement risk in U.S. dollars - a *currency-specific friction*. We now turn to how this friction might not be at play in the euro-system’s jurisdictional approach.

EU Opposition to Extra-territorial Jurisdiction

Why does a centralised euro payment system not give the EU an extraterritorial reach comparable to that of the U.S.? The answer lies in the EU’s longstanding opposition to the extraterritorial use of sanctions, shaped by its opposition to U.S.

²⁰The report highlights how de-risking of correspondent bank relationships has been particularly pronounced in the U.S. dollar, where correspondent activities have become increasingly concentrated in U.S. banks while non-U.S. banks have withdrawn from offering dollar services except for limited ancillary functions.

²¹See U.S. Department of the Treasury, Office of Foreign Assets Control, *Economic Sanctions Enforcement Guidelines*, 31 C.F.R. Part 501, Appendix A: “OFAC may impose civil penalties on a strict liability basis,” <https://ofac.treasury.gov/faqs/topic/1626>.

sanctions binding EU firms in foreign markets. The 1996 “Blocking Statute,”²² adopted in response to U.S. measures on Cuba, Iran, and Libya, prohibits EU operators from complying with certain third-country laws with extraterritorial effect, although its actual effectiveness in doing so has been questioned. Consistent with this stance, the definition of “EU persons” encompasses only EU nationals, entities incorporated under Member-State law, and any person or activity located within EU territory. In the case of the U.S. Russia sectoral sanctions adopted in 2014, the scope of “U.S. persons” was aligned with this definition. However, the broader U.S. sanctions framework has historically adopted a wider conception of jurisdiction: in several regimes—most notably those concerning Iran and Cuba—U.S. prohibitions extend to foreign entities owned or controlled by U.S. persons. By contrast, EU sanctions have not explicitly bound foreign subsidiaries of EU companies.²³

More importantly, euro payments do not create an automatic “EU nexus” analogous to the U.S. nexus in dollar transactions, i.e. non-EU counterparties are not brought under EU jurisdiction merely by using the currency²⁴. Indeed, EU opposition to extra-territoriality of sanctions jurisdiction was strongly reaffirmed over 2014-2021. The 2017 Countering America’s Adversaries Through Sanctions Act (CAATSA), which potentially provided the basis for a broader application of secondary sanctions targeting EU companies involved in gas pipelines projects in Russia²⁵, prompted a strong political reaction by EU leaders²⁶. Opposition to extra-territoriality was further reaffirmed following the withdrawal of the U.S. from the

²²Council Regulation (EC) No 2271/96 (OJ L 309, 29.11.1996); European Commission, “Blocking Statute: Protecting EU Operators from the Extraterritorial Application of Third-Country Laws,” 2022.

²³Council Regulation (EU) No 833/2014, Arts 12–13. Foreign branches of EU entities, lacking separate legal personality, are generally covered, whereas subsidiaries incorporated under non-EU law are not, unless the EU parent knowingly participates in their activities. This interpretation prevailed during 2014–2021, though recent guidance hints at a gradual shift toward a stricter, control-based approach.

²⁴See European Commission, *Guidance Note on the Implementation of Council Regulation (EU) No 833/2014* (2022), Section 1, and European External Action Service (EEAS), “EU Sanctions: How and When They Are Applied”.

²⁵See Fried and O’Toole (2017).

²⁶The German foreign minister and the Austrian chancellor jointly declared “*We cannot accept the threat of illegal extraterritorial sanctions against European companies*”, *Berlin hits back at U.S. move to tighten sanctions on Russia*, Financial Times, June 15, 2017.

Iran’s Joint Comprehensive Plan of Action and the reinstatement of U.S. sanctions against Iran on May 8, 2018. On June 6, 2018 the European Commission issued an update to its Blocking Statute, extending its application to the re-imposed extra-territorial U.S. sanctions against Iran.

Furthermore, it is to be noted that enforcement of sanction regulations in the EU entirely relies on national authorities, rather than a centralised, specialised enforcement arm such as the U.S. OFAC.

Perceptions of U.S. Dollar Settlement Risk by Market Participants in 2014

Issues around foreign currency settlement risk for Russian sanctioned entities became topical following the full-scale blocking sanctions against Russia in 2022 (Breydo, 2022; Bradley et al., 2022), among a technical default of some Russian sovereign bonds and substantial delays in coupon payments on Gazprom’s Eurobonds, both caused by Western blocking measures. However, there is ample evidence that market participants were fully aware of U.S dollar settlement risk in jurisdictions with high sanction compliance risk as soon as 2014.

In June 2014, the U.S. Department of Justice and OFAC imposed nearly \$9 billion in penalties on BNP Paribas for processing U.S.-dollar transactions through the U.S. financial system on behalf of clients in Sudan, Iran, and Cuba, in violation of U.S. sanctions.²⁷ The case, which included a one-year suspension from direct dollar clearing,²⁸ brought the compliance obligations of USD correspondent banks — and their exposure to U.S. sanctions enforcement — to the forefront of market participants’ attention.

²⁷U.S. Department of Justice, “*BNP Paribas Agrees to Plead Guilty and to Pay \$8.9 Billion for Illegally Processing Financial Transactions for Countries Subject to U.S. Economic Sanctions*,” June 30, 2014, <https://www.justice.gov/archives/opa/pr/bnp-paribas-agrees-plead-guilty-and-pay-89-billion-illegally-processing-financial>.

²⁸Office of the Governor of New York, “*Cuomo Administration Announces BNP Paribas to Pay \$8.9 Billion, Including \$2.24 Billion to DFS, Terminate Senior Executives, Restrict U.S. Dollar Clearing Operations for Violations of Law*,” June 30, 2014, <https://www.governor.ny.gov/news/cuomo-administration-announces-bnp-paribas-pay-89-billion-including-224-billion-dfs-terminate>

Following the 2014 sectoral financial sanctions on major Russian banks and energy companies — large and frequent participants in global capital markets — the issue of dollar-settlement risk for unsanctioned Russian entities came sharply into focus. In early 2015, London-based lawyers at Clifford Chance observed that sanctions clauses had become central to Russian loan documentation and that “currency-toggle” provisions were increasingly incorporated into cross-border loan contracts involving Russian borrowers (Fadian, 2015). These clauses, while keeping contracts denominated in dollars, permitted payment in an alternative currency in case the borrower was prevented access to dollar clearing.

A similar pattern materialised in the Russian Eurobond market when large non-sanctioned Russian entities resumed primary market issuance for the first time after the invasion of Crimea, in the Spring of 2016. Strikingly, Russia’s 2026 USD Eurobond issued in 2016 included an “Alternative Payment Currency Event Clause” allowing repayment in euros, pounds sterling, or Swiss francs if dollar payments became impossible for reasons beyond the issuer’s control. In the run up to the 2022 full-scale invasion of Ukraine, similar clauses later appeared in corporate bond issues by Gazprom, even allowing repayment in rubles.

These contractual innovations illustrate how concerns over U.S.-dollar settlement risk became embedded in Russian cross-border financing after 2014. From the point of view of both lenders and borrowers, an obvious alternative to such complex and, arguably, “exotic” contractual clauses would have been an outright shift in the currency of denomination of loans. Given its rank as the second most widely used international currency, strong trade links between Russia and the EU and the absence of extra-territorial application of EU law, the euro represented the best alternative to the U.S. dollar in this regard.

Proposition 2 *Following the 2014 sanctions, non-USD denomination of global banking claims on Russia should increase relative to USD denomination, for all jurisdictions, regardless of whether they imposed sanctions on Russia. This follows from the extra-territorial enforcement of U.S. sanctions, which embeds legal*

jurisdiction in the dollar payment system and exposes all dollar transactions to compliance risk. Euro-denominated payments do not entail a comparable exposure, given a more fragmented enforcement apparatus and traditional EU opposition to extra-territorial jurisdiction. This asymmetry generates higher settlement risk in U.S. dollars relative to euros, driven by higher compliance costs for U.S dollar correspondent banks handling Russian-related settlements, particularly in borrowing jurisdictions with high sanction compliance risk.

1.3 Data

In this section we describe the different data sources employed in our analysis on the effects of sanction risk on cross-border credit allocation and vehicle currency usage. We start by presenting the dataset on corporate liabilities by currency, and the one on UK-based global banks’ cross-border positions. Then we describe our dataset on global syndicated loans and, finally, the Locational Banking Statistics from the BIS.

Capital IQ We source firm-level outstanding liabilities by currency and debt instrument from S&P Capital IQ. The dataset includes active and inactive public and private ultimate-parent companies filing financial statements. This information is available mostly at annual rather than quarterly frequency. Liabilities are grouped into Bonds and Notes, Term Loans, Capital Leases and Other Borrowing. We use this data to calculate the stocks and shares of principal due by Russian firms by currency of denomination, which we use to understand the shift in Russian companies’ debt structure, depending on whether they are subject to the 2014 sectoral sanctions, in Section 1.4.

We perform a series of cleaning steps in line with the literature (Adams and Verdelhan, 2022; Rodnyansky et al., 2022; Alfaro, Caballero et al., 2025; Boyarchenko and Elias, 2024), and some novel ones specific to our analysis of the effects of financial sanctions. First, we keep observations corresponding to the latest filing for each fiscal year starting in 2001, when the debt structure data becomes more comprehensive. Second, following Lou and Otto (2020), we drop items corresponding to a “facility”, as this indicates total *available* credit rather than withdrawn. Third, we aggregate our dataset from instrument to the company-currency-year level.²⁹ Fourth, we manually check our sample of Russian firms from CIQ against the list of sectoral sanctions issued by the US and the EU (Table A.1) to identify the sanctioned firms sample. In line with the literature using CIQ data, we focus on ultimate parents (“operating” firms) , to avoid any double counting

²⁹This also helps with circumventing the issue that identifiers of each debt instrument in CIQ might change over time, so it is difficult to keep track of the same component of liabilities across time.

due to the consolidated nature of CIQ data. Another reason is that the detailed capital structure data for non-operating firms (subsidiaries) are less granular and suffer from some reporting gaps.³⁰

Finally, we augment the dataset with additional balance sheet information sourced from Capital IQ itself. These include total assets, total liabilities, total equity, revenues, EBITDA, operating income, interest expenses, currency of statements, SIC sector, country of incorporation, immediate and ultimate owner.

UK Resident Banks Global Claims by Currency The Bank of England’s confidential quarterly panel of bank unconsolidated balance-sheet data includes information on banks’ cross-border claims³¹ and liabilities³² on non-residents. The dataset collects submissions from domestic and foreign-owned banks operating in the UK through regulatory filings and statistical data forms. We leverage this dataset to create a panel of banks’ positions towards non-residents by asset, country, and currency over the post-GFC sample 2010 to 2023.

This source of cross-border banking data has been used by other studies on a variety of topics.³³ With respect to other financial centres, UK-resident banks dominate global cross-border banking, with their claims nearly twice as large as those of US-based banks on average (Bippus et al., 2024). The dataset is therefore typically considered as a representative sample of global banking flows. As shown in Figure A.1, which depicts total cross-border credit flows to Russia as reported to the BIS by residency, cross-border credit to Russia extended by UK-resident banks account for a sizeable share of total cross-border lending to Russia (around

³⁰This means our core sanctioned sample does not include Gazprom Neft, a subsidiary of Gazprom Group, itself not subject to sectoral financial sanctions, and Rostec, a state owned defence conglomerate which does not file financial statements. We still collect available data on the detailed capital structure of Gazprom Neft and all of Rostec subsidiaries reported in CIQ. Given the smaller size of these firms compared to the rest of the sanctioned sample and the fact that they behave very similarly in terms of the evolution of their debt profile, their exclusion is unlikely to alter our baseline results. We show in the Appendix in Figure A.3 the profile of total debt by currency for those firms, as reported in CIQ

³¹<https://www.bankofengland.co.uk/statistics/data-collection/statistical-reporting/form-cc>.

³²<https://www.bankofengland.co.uk/statistics/data-collection/statistical-reporting/form-cl>.

³³Including Aiyar et al. (2014), Forbes et al. (2017), Bussière et al. (2021), Andreeva et al. (2023), Eguren-Martin et al. (2024), Lloyd et al. (2023) and Bippus et al. (2024).

30%, before 2014), although this share declined after 2014 with the rise of claims reported from residual “other” jurisdictions.

In our analysis we consider only cross-border lending in the form of loans and advances.³⁴ We also maintain the country dimension of the panel in order to be able to compare flows to specific economies, in particular Russia, against others. This leaves us with a sample spanning from 2010 Q1 to 2023 Q4, and including 285 banks, 231 countries³⁵ and 6 currency groupings (GBP, USD, EUR, JPY, CHF and a residual group labeled others “OTH”), for a total of 31,992 unique bank-country-currency combinations.

At aggregate level our sample is dominated by established “continuers” banks: around 80% of the aggregate loans and advances position in every quarter is accounted for by banks which report every quarter in our sample. A smaller proportion of banks enter and exit the dataset over our sample, but we cannot easily distinguish these dynamics from bankruptcy or new establishments because of the reporting thresholds applied to the reporting forms.

Although we focus on claims, we provide some information on the dynamics of cross-border liabilities, specifically cross-border deposits.³⁶ Following the same cleaning process as for the claims’ dataset, our selected sample going from 2010 Q1 to 2023 Q4 includes 271 banks, 231 countries, for a total of 40,331 unique bank-country-currency combinations (with the same 6 currency groupings as above).

Syndicated Loans We source information on global syndicated loans from Refinitiv LoanConnector DealScan over a sample going from 2010 to 2019. In a syndicated loan transaction, a borrower takes out a “deal” from a group, a “syndicate”, of lenders. This deal includes several loans, called “tranches”. This is the

³⁴Specifically, we consider the flows labelled “loans and advances, and claims under sale and repurchase agreements”, and add up the sectors “non-resident deposit taking corporations (incl. CMIs)” and “other non-residents”.

³⁵We dropped observations where countries of non-resident counterparties were not disclosed. We did so as we could not identify them, and to be sure to exclude observations from potentially sanctioned countries from our analysis.

³⁶We consider the flows labelled “sight and time deposit liabilities and liabilities under sale and repurchase agreements”, and add up the sectors “non-resident deposit taking corporations (incl. CMIs)” and “other non-residents”, as done for claims.

relevant level for currency denomination. The dataset includes quantitative and qualitative info at the lender-borrower-loan level: we observe borrower and lender identifiers, loan type, purpose, maturity, interest rate and spreads over benchmark rates, currency, and lending amount.

Syndicated loans are economically relevant and representative of global capital flows. Total cross-border syndicated lending to non-financial firms represents around three-quarters of the total volume of cross-border bank lending to non-financial borrowers (Doerr and Schaz, 2021). Syndicated loans comprised 30% of total global cross-border debt in 2012 Q4, and 46% for emerging markets (Elliott, Meisenzahl and Peydró, 2024).

We focus on *origination*, and exclude any subsequent amendment to the same loan. In line with the literature, we perform pro-rata splits whenever exact loan shares by lenders are not available — this has been shown to be a reasonable approximation to the actual split (Doerr and Schaz, 2021; Aldasoro et al., 2022). To measure the size of tranches, we rely on the U.S. dollar tranche value provided by DealScan and convert it to 2015 U.S. dollars. We are however particularly interested in prices of syndicated loans, as this is the key advantage of the DealScan data compared to the banking claims data we rely on in the rest of the paper. Although prices are typically not available for most deals in DealScan, the available coverage is sufficient for us to analyse a large enough sample of loan prices in Section 1.6. To this effect, we fill some gaps in DealScan pricing information for Russian firms by manually inputting the currency, maturity, prices and benchmark rate of syndicated loans for which this information is missing in DealScan and we were able to collect it from the financial statements of Russian companies³⁷.

Our final sample contains 80,233 loans (tranches), 32,014 borrowers, 7,082 lenders, 140 lenders' and 173 borrowers' countries over the period 2010-2019. Finally, we group countries in Advanced Economics and Emerging Markets following

³⁷This chiefly concerns Gazprom Group, for which we were able to retrieve missing informations on pricing, maturity and currency of denomination of existing DealScan deals for 13 deals after 2014, relying on Gazprom's own IFRS financial filings retrieved in Capital IQ.

the IMF classification.³⁸ Following De Haas et al. (2025), we aggregate our syndicated loan dataset at the bank-borrower-currency-year level. This means that in the empirical analysis in Section 1.6 our variables of interests are the total volume lent and the volume-weighted average spread at the bank-borrower-currency-year level.

Locational Banking Statistics The Bank for International Settlements’ (BIS) Locational Banking Statistics (LBS) provides the key stylised fact that motivates this paper, by looking at the evolution of the currency breakdown of global claims on Russia. Furthermore, we use it as a complementary data source to link our empirical findings in firm, bank and loan-level data to aggregate patterns and the literature on geoeconomic power. The LBS provide quarterly data on the outstanding positions of internationally active banks disaggregated by reporting *and* counterparty country, sector, and currency of denomination. Crucially for our analysis, the BIS data allows us to identify lenders’ countries both on a residence and nationality basis. To quantify the evolution of U.S. geoeconomic power in Russia we mainly focus on the nationality basis 1.7.³⁹

Notice how we must employ the restricted version of the public dataset for our analysis of the evolution of geoeconomic power in the final section 1.7. This is because the public version of the LBS does not report jointly currency splits *and* country breakdowns, no matter whether we are considering a residence or nationality basis.

Our final dataset on a nationality basis includes 39 countries reporting claims on Russia across 6 currency groupings, i.e. USD, EUR, CHF, GBP, JPY, and a residual category. Furthermore, our equivalent sample on a residence-basis includes 44 countries reporting claims on Russia aggregated across the same currency groupings.

³⁸See Table A. Economy Groupings in Fiscal Monitor, Oct 22.

³⁹From the nationality-basis dataset we drop consortium banks, non-reporting developing Africa and Middle East, non-reporting developing Asia and Pacific, non-reporting developing Europe, non-reporting developing Latin America and Caribbean, all-countries totals, unallocated locations, and non-reporting developed countries. From the residence-based dataset we drop currency and country aggregates, as well as unallocated currency entries.

1.4 The Effect of the 2014 Financial “Sectoral” Sanctions on Russian Firms’ Balance Sheets

This section provides some stylised facts as well as estimates on the impact of the 2014 financial sanctions on the capital structure of targeted and non-targeted Russian firms. Relying on Capital IQ data, we are able to analyse the balance sheets and the currency composition of the liabilities of all Russian firms under sectoral sanctions, as well as a large sample of non-sanctioned Russian firms and emerging markets firms active in global capital markets. Compared to the rest of the paper, we therefore implicitly broaden our analysis to marketable debt and other non-bank financing, which we do not observe in the rest of the paper. Similarly, the data we observe in this section also include lending to Russian firms by domestic lenders, in domestic and foreign-currency.

The key purpose of this section is to clarify our findings in the more granular banking and loan data we analyse below, and to rule out that euro lending flowed to *sanctioned* Russian firms, i.e. that euroisation had anything to do with sanction avoidance practices.

We show that overall debt levels and dollar denominated principal declined across all Russian firms, regardless of their sanctioning status. However, only firms that were not under sanctions managed to increase their euro denominated debt, ruling out any role of sanction avoidance in the increase of euro-denominated flows to Russia. Sanctioned firms also experienced a substantial increase in interest payments and debt-burden levels compared to non-sanctioned firms.

1.4.1 Stylised Facts on Russian Firms after the 2014 Sectoral Sanctions

We concentrate our analysis on operating firms, i.e. parent companies. This is economically sensible as sanctions on a subsidiary that do not simultaneously target the parent are likely to induce intra-group reallocation of claims⁴⁰. The relevant

⁴⁰This concerns Gazprom Neft in our sample, as Gazprom Group is not itself sanctioned by the U.S. and the EU, and remains one of the larger borrowers in international markets.

object to study debt structure shift is indeed the consolidated statements at the parent level⁴¹ The aggregate figures for sanctioned firms in the Panels of Figure 1.2 therefore comprise all but two of the firms under Western sectoral sanctions, as listed in Table A.1.⁴²

We define a comparable sample of non-sanctioned Russian firms in the following way. First, we exclude any firm that did not have at least 1bn USD of U.S dollar denominated principal in 2013 from our universe. This is in line with the dollar indebtedness of the smallest firms under sectoral sanctions⁴³. Second, we manually check on opensanctions.org that no Russian firm in the non-sanctioned sample was subject to sanctioning measures other than sectoral sanctions during 2014-2021.⁴⁴

Figure 1.2 provides a first striking stylised fact. The overall debt level of sanctioned firms declined significantly more after 2014 than for non-sanctioned firms.⁴⁵ Sanctioned firms also saw a more marked decline in their leverage ratio and a striking increase of their debt burden compared to non-sanctioned firms. This suggested that sanctions achieved their intended effect and tightened financial conditions more for firms designated in the sectoral sanctions list.

A second key stylised fact is depicted in Panels (c) and (d) of Figure 1.2. Both sanctioned and non-sanctioned firms de-dollarised their balance sheet, reducing their principal due denominated in U.S. dollar both in absolute levels and as a share of total debt. However, only firms that were not designated under sectoral sanctions increased their euro-denominated debt. The substitution of dollar with

⁴¹This leads us to exclude Rostec from the analysis, a government-owned defense conglomerate which does not publish consolidated financial accounts.

⁴²Consolidated data for the Rostec group is not available in Capital IQ. Rostec is a defense conglomerate that does not publish financial accounts, although some of its subsidiaries do. As mentioned above, Gazprom Neft is a subsidiary of Gazprom Group, which is itself not subject to financial sectoral sanctions. Although we exclude Rostec’s subsidiaries and Gazprom Neft from the evidence presented in this section, equivalent charts looking at their debt profile and currency composition can be seen in Figure A.3, although data has some gaps in continuous coverage. As they are by far the smallest firms under sectoral sanctions and the trends presented in Figure A.3 are all but similar to the ones of sanctioned operating firms, this exclusion is unlikely to change our key firm-level results.

⁴³Both United Aircraft Corporation and Gazprom Neft had between 3 and 4bn of USD denominated debt in 2013.

⁴⁴This yields a sample of between 15 and 17 non-sanctioned Russian firms in 2010-2020.

⁴⁵Although this was driven by rising local currency liabilities in the financial sector firms prior to 2014, this sectoral heterogeneity is addressed in the empirical section below.

euro liabilities for non-sanctioned firms only is consistent with the relative increase in dollar settlement risk that underlies our Proposition 2 above. The fact that sanctioned firms were not able to increase their euro liabilities also rules out the hypothesis that banks relied on euro flows as part of sanction avoidance strategies.

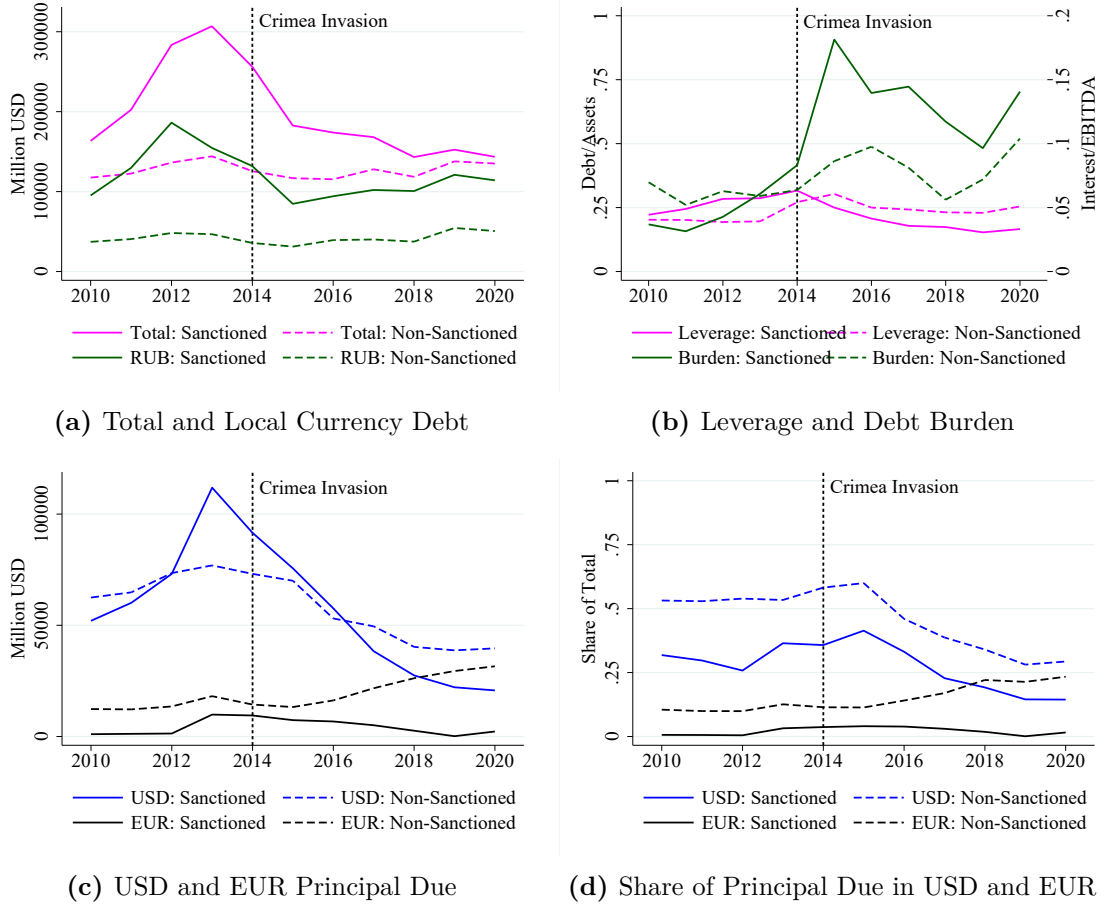


Figure 1.2: Debt Profile and Currency Composition of Russian Firms by Sanctioning Status.

Note. — Operating companies only. Sanctioned firms cover the full universe of operating firms under sectoral sanctions except for Rostec. Non-sanctioned firms cover the sample of Russian firms with at least 1bn USD-denominated debt in 2013.

Source: Capital IQ, authors' calculations.

1.4.2 The Effect of the 2014 Sectoral Sanctions on Debt Levels and Currency Denomination

We now provide some further quantification on the effect of the 2014 sectoral sanctions on the capital structure and currency composition of debt for both

sanctioned and non-sanctioned firms. We expand our sample to a non-Russia control group of firms with at least 1bn USD of U.S. denominated debt in 2013. In our preferred specification, we further restrict the control group to only emerging markets comparable to Russia in terms of size, geopolitical alignment and relative levels of economic integration with the EU.⁴⁶ We look at a sample from 2010 to 2020.⁴⁷

We then estimate the following Difference-in-Difference (“DiD”) regression

$$Y_{it} = \beta_1 \cdot \text{Post}_t \times \text{Russia}_i + \beta_2 \cdot \text{Post}_t \times \text{Russia}_i \times \text{Sanctioned}_i + k + \varphi_i + \varphi_{st} + \varepsilon_{it} \quad (1.4.2.1)$$

where Y_{it} is a variable of interest varying across firms and time, Post_t is a dummy variable equal to one from 2014 onward, Russia_i is a dummy variable equal to one if the firm operates from Russia and Sanctioned_i is a dummy variable equal to one if the firm is a sectoral-sanction designated firm. We include firm and sector-time fixed-effects in all specifications. The latter help us absorb endogenous difference across sectors in debt levels and their currency composition, including aggregate sectoral trends and shocks.

Table 1.1 and 1.2 provide results from Equation 1.4.2.1 on selected measures of leverage and debt burden. The results suggest that, within-firm, and once-controlling for sectoral trends, the 2014 sectoral sanctions led to a symmetric decline in overall debt levels for sanctioned and non-sanctioned Russian firms, by about -30% compared to the emerging markets control group. They also confirm that only sanctioned firms were forced to deleverage compared to the control group, as they experienced a four-fold increase in interest expenses and a substantial increase in debt burden.⁴⁸

⁴⁶BRICS+ and CEEMEA countries.

⁴⁷The post-2022 period is outside of the scope of this paper as the sanctioning regime substantially tightens along many dimensions. We also exclude 2009 as it coincides with the Global Financial Crisis. Additionally, gaps in data availability for some of the large Russian firms of interest appear in Capital IQ after 2020, limiting our analysis to 2010-2020.

⁴⁸Notice that the coefficients from the tables need to be exponentiated to derive the exact percentage change in the dependent variable of interest.

Table 1.1: Firm-Level Debt and Leverage

	Total Debt			Leverage		
	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD
Post $\times$ Russia	-0.363*** (0.098)	-0.289*** (0.085)	-0.321*** (0.085)	-0.042*** (0.010)	0.074 (0.053)	0.066 (0.052)
Post $\times$ Russia $\times$ Sanctioned			-0.013 (0.084)			-0.084* (0.044)
Estimator	OLS	OLS	OLS	OLS	OLS	OLS
Observations	937	1,049	1,128	937	1,049	1,128
R-squared	0.906	0.898	0.902	0.841	0.821	0.822

Estimating sample includes firms in Russia, BRICS+ and CEEMEA emerging markets with more than 1bn USD denominated debt in 2013. Firm and sector-time fixed effects are included in all specifications. Standard errors are clustered by country. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 1.2: Interest Expenses and Debt Burden

	Interest Expenses			Debt Burden		
	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD
Post $\times$ Russia	1.417*** (0.290)	-0.149 (0.158)	-0.150 (0.163)	1.488*** (0.217)	0.052 (0.134)	0.074 (0.135)
Post $\times$ Russia $\times$ Sanctioned			1.452*** (0.078)			1.298*** (0.123)
Estimator	OLS	OLS	OLS	OLS	OLS	OLS
Observations	529	677	701	491	641	665
R-squared	0.862	0.858	0.863	0.839	0.844	0.847

Estimating sample includes firms in Russia, BRICS+ and CEEMEA emerging markets with more than 1bn USD denominated debt in 2013. Firm and sector-time fixed effects are included in all specifications. Standard errors are clustered by country. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.2 and A.6 then turn to results from Equation 1.4.2.1 looking at the currency composition of debt. Regressions of debt levels by currency are estimated with PPML on a panel that includes “zero” observations, so as to account for both the intensive and extensive margin, particularly in euro-denominated debt. It confirms that all Russian firms in our sample reduced their dollar denominated debt, by 45% compared to the control group, regardless of whether they were designated in the sectoral sanctions list, as shown by the insignificant estimate on the triple interaction term in the USD Debt - DiD column of Table A.2. Similarly, all Russian firms reduced their debt in domestic currency, i.e. the Ruble, but sanctioned firms almost twice as much as non-sanctioned. Euro-denominated debt levels, on the other hand, increased significantly only for non-sanctioned firms and by 110%, while the increase for sanctioned companies is insignificant, as shown by the corresponding “Sanct. total” row under the EUR Debt - DiD column.

Finally, following the approach by Lewis and Xie (2025), we bring together these separate regressions into a single one with USD as base currency. This means that we can run the following regression:

$$\begin{aligned}
Y_{ict} = & \beta_1 \cdot \text{Post}_t \times \text{Russia}_i \times \text{EUR}_c + \beta_2 \cdot \text{Post}_t \times \text{Russia}_i \times \text{Sanctioned}_i \times \text{EUR}_c \\
& + \beta_3 \cdot \text{Post}_t \times \text{Russia}_i \times \text{Dom}_c + \beta_4 \cdot \text{Post}_t \times \text{Russia}_i \times \text{Sanctioned}_i \times \text{Dom}_c \\
& + k + \varphi_{it} + \varphi_{ct} + \varphi_{ic} + \varepsilon_{ict}
\end{aligned}
\tag{1.4.2.2}$$

which allows for the introduction of tighter firm-year, currency-year and firm-currency fixed effects. Consistently with the disaggregated results, we find that all Russian firms have significantly substituted USD debt for liabilities denominated in EUR and domestic currency.

We provide some robustness tests and extensions in Appendix A.2. Tables A.3, A.4 and A.5 provide similar results including in the control group all firms with at least 1bn USD of U.S. dollar denominated debt in 2013, without selecting for Russia-comparable emerging markets. Our findings are broadly confirmed.⁴⁹ Table A.6

⁴⁹We note that the increase in EUR debt across firms is positive but insignificant, highlighting the importance of selecting a suitable control group for Russia to tease out the sanction-driven rise in EUR denomination of debt.

reports equivalent results for currency shares as in Table A.2, and A.4 a robustness test expanding again the sample.⁵⁰

There are three key take-aways from our firm-level analysis. First, the 2014 sectoral sanctions managed to inflict targeted damage on sanctioned firms, which disproportionally experienced an increase in interest payments and a deterioration of their debt burden.

Second, our results are consistent with regulatory de-risking by foreign lenders playing an important role in post-2014 Russia cross-border capital flows, as overall debt declined substantially across all Russian firms in our sample, regardless of their sanctioning status.

Third, the firm-level currency patterns we uncover are consistent with higher relative settlement risk in U.S. dollar relative to other currencies and, particularly, the euro. Non-sanctioned firms partially substituted dollar-denominated debt with euro-denominated debt. We find no indication that sanctioned firms were able to raise euro debt in any meaningful way after 2014, suggesting that the management of sanction compliance risk, as opposed to sanction avoidance practices, was the driver of the euro-isation of Russian cross-border flows.

⁵⁰Note that the observations for the EUR share OLS regressions are larger than those for the EUR debt PPML regression. This is because some zeros are perfectly predicted by the fixed effects and, as under PPML those are removed, some observations might become separated under the high-dimensional fixed effects. OLS does not incur in this “separation” problem.

1.5 Jurisdiction and Currency Frictions in Bank-Level Lending to Russia after 2014

In this section we directly test the propositions set forward in Section 1.2, namely the fact that sanction-compliance risk is likely to introduce both jurisdiction and currency-specific de-risking in international capital flows. We rely on bank-level confidential data on global claims of UK resident banks by currency and counterparty country collected by the Bank of England. We begin by showing that the global aggregate stylised fact we uncover in the BIS locational banking data is also present in our confidential bank-level panel focusing on the universe of UK resident banks (Section 1.5.1). We then show the relevance of both the jurisdiction and currency margins in explaining aggregate patterns in cross-border lending to Russia from the City of London, by providing a detailed decomposition by jurisdiction and currency (Section 1.5.2). Finally, we empirically test Propositions 1 and 2, and disentangle the relevance of jurisdiction and currency frictions within-banks. We start by testing these propositions on claims on Russia by UK resident banks after 2014. We furthermore test whether banks i) exposed to claims on Russia immediately before the invasion of Crimea, ii) to a sanctioning coalition jurisdiction, or iii) both, changed their lending patterns to other emerging-markets following the 2014 sectoral sanctions on Russia along similar dimensions (Section 1.5.3).

1.5.1 Stylised Facts

We begin by showing that lending to Russia from UK-resident global banks broadly followed the aggregate patterns shown in Figure 1.1 over our period of interest, looking at aggregated confidential data from the Bank of England. As shown in panel (a) in Figure 1.3, lending to Russia from UK-resident global banks dropped starkly after 2014 both in absolute terms, going from around 25 to 7bn GBP (Figure A.5), and as a share of overall lending to non-UK residents. Panel (b) shows that this decline coincided with a sharp reduction in the number of banks extending loans and advances to Russia.

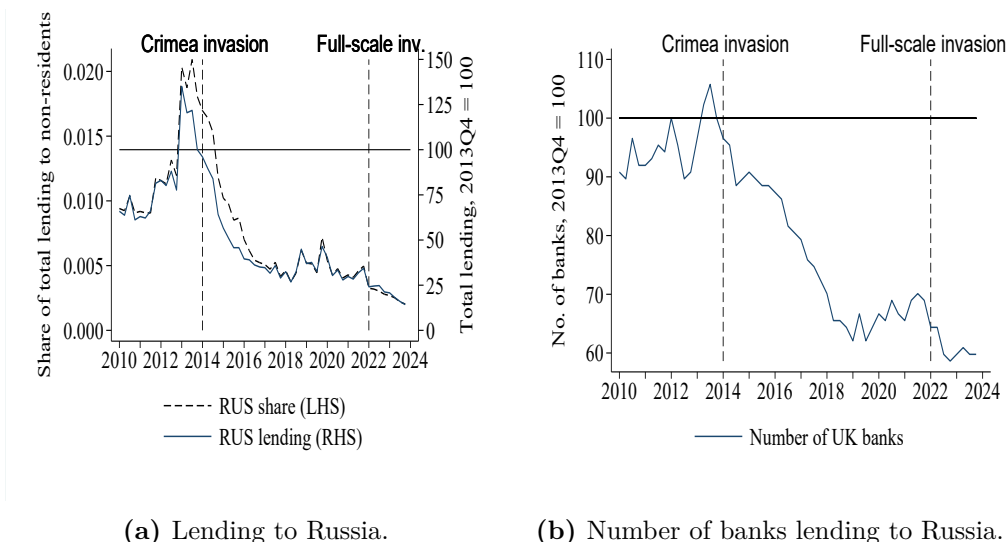


Figure 1.3: Global banks' total lending to Russia.

Note. – Lending and number of banks are indexed to be 100 in the fourth quarter of 2013, that is the quarter before Russia's invasion of Crimea. Proportion of Russia lending out of total non-resident lending is in simple shares from 0 to 1.

Source: Bank of England's dataset on claims of UK banks on non-residents.

Similarly to the global aggregates in the BIS Locational Data, the 2014 invasion of Crimea coincides with a dramatic shift in the currency composition of international lending. Panel (a) and (b) in Figure 1.4 compare the currency composition of banks' claims on Russia to those on the Rest of the World (RoW)⁵¹ Lending to Russia underwent a stark *de-dollarisation* in favour of a *euroisation* of cross-border claims, as well as an increase in the use of other currencies to a smaller extent. Before 2014 around 80% of UK resident banks lending to Russia was in USD. By 2019 the euro and the U.S. dollar represented a similar proportion of claims at around 40%.⁵²

As shown in Figure 1.1, BIS Locational Banking data report an even more striking overall de-dollarisation, with the share of euro claims, also at around 40% in the aggregate BIS data, now almost double the share of global dollar

⁵¹Excluding other countries subject to U.S. financial sanctions as measured by the Global Sanctions Data Base (Felbermayr et al., 2020; Yalcin et al., 2025).

⁵²Figure A.6 in the Appendix shows that these results are robust to winsorising lending claims to ensure that the quarterly growth of cross-border positions is bounded between -100% and $+100\%$, as done in other studies that use this dataset (Bussière et al., 2021; Andreeva et al., 2023; Lloyd et al., 2023; Bippus et al., 2024).

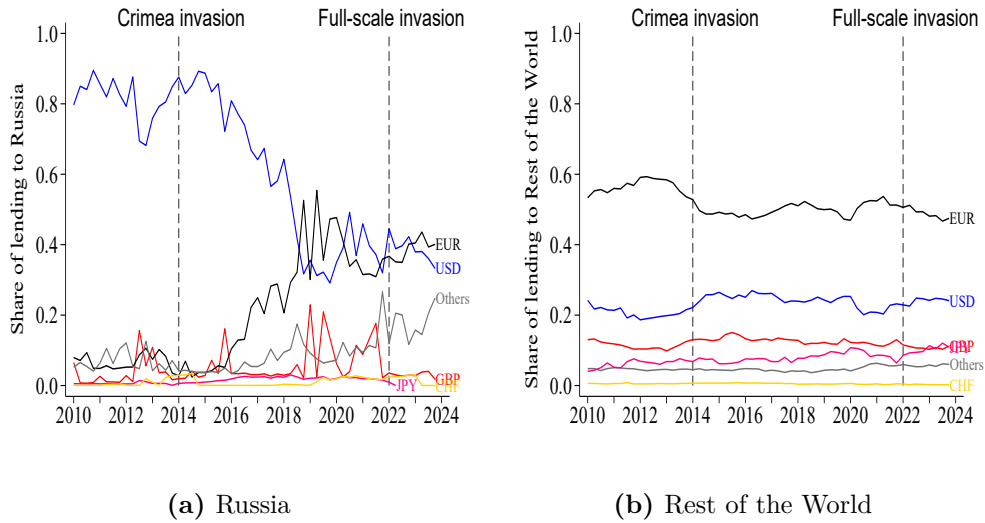


Figure 1.4: Currency composition of lending to non-residents.

Note. – Proportion of each currency group out of total lending to Russia and Rest of the World is in simple shares from 0 to 1. Rest of the World includes only countries not subject to U.S. financial sanctions as measured by the Global Sanctions Data Base (Felbermayr et al., 2020; Yalcin et al., 2025).

Source: Bank of England’s dataset on claims of UK banks on non-residents.

claims to Russia.

In what follows, we exploit the granularity of the BoE confidential bank-level data on UK-resident banks, rather than aggregate BIS data. Note that UK-resident global banks cover a large portion of overall lending to Russia: about a third of the pre-2014 stock, comparing panels (a) in Figures A.5 and 1.4. We first ask whether the propositions set out in Section 1.2 are consistent with aggregate patterns via a detailed decomposition exercise.

1.5.2 Bank-Level Margin Decomposition of Euro Claims to Russia

Which banks drove the remarkable shift in global credit flows to Russia, looking at both the large drop in total credit and the change in composition from U.S. dollars to the euro? Building on Bernard et al. (2009), we assess which margins contributed to the changes in lending to Russia performing the following decomposition on our bank-level data:

$$\Delta l_{t-\tau}^c = \underbrace{\sum_b \Delta l_{b,t-\tau}}_{\text{Entry}} + \underbrace{\sum_b \Delta l_{b,t-\tau}}_{\text{Exit}} + \underbrace{\sum_b \Delta l_{b,t-\tau}}_{\text{Continuers}} \quad (1.5.2.1)$$

Equation 1.5.2.1 decomposes the overall change Δ in lending y in currency c from time τ to t into three parts. First, the contribution by new entrants, that is banks that were not reporting lending in c to Russia at time τ , but did so at time t . Second, the contribution of exiting banks, that is banks that were reporting lending in c to Russia at time τ but no longer do so at quarter t . Finally, the contribution of increases or decreases in lending by “continuing banks” that were already lending to Russia in time τ and kept doing so, but to a different extent, in time t .

Figure 1.5 reports the baseline results of this exercise using 2013 Q4 as the benchmark τ for the banking claims on Russia for the U.S. dollar and the euro, respectively in panel (a) and (b).⁵³ Two main points emerge.

First, the vast majority of the decrease in U.S. dollar lending is accounted for by a reduction along the intensive margin, with continuing banks lending in U.S. dollars less than before 2014. From 2017 onwards, banks also started to exit altogether dollar positions in Russia.

Second, the increase in euro lending from 2016 Q1 onwards appears to be driven by the intensive and extensive margins alike: incumbent banks increasing their supply of euros, and new entrants providing a new source for euro-denominated loans and advances, respectively.

An obvious question that arises is whether the same banks that cease to lend in dollars shift their Russian exposure to euros. As a next step we therefore further decompose the evidence in panel (d) of the same Figure 1.5, and specify whether euro lenders to Russia were previously exposed to dollar claims to Russia or not. The overwhelming majority of the increase in euro lending to Russia was indeed driven by banks previously exposed to dollar claims to Russia. Interestingly, half

⁵³Equivalent decompositions for the British pound and the residual "Other" currencies are shown in Figure A.10. For completeness, we include the corresponding charts grouping all countries other than Russia in Figure A.11 in the Appendix. Note there is no de-dollarisation, lending increases in all currencies since 2014.

of the increase in euro lending to Russia is due to banks that were never exposed to euro Russian claims before 2014. All in all, banks exposed to Russia that continued to provide new credit after the imposition of the 2014 sectoral sanctions overwhelmingly did so in euros rather than in dollars.

A second, related question is the nationality of the UK-based global banks that provided euro financing to Russia after 2014 and whether new credit was dominated by banks ultimately based in non-sanctioning jurisdictions. We assign our sample of banks to a certain jurisdiction based on the nationality of its ultimate parent, and further decompose the increases in euro lending by ultimate jurisdiction of the bank. The outcome of this exercise depicted in panel (f) of Figure 1.5 suggests a clear additional takeaway.⁵⁴ Although the first leg of increases in euro lending occurring in 2016 seems to be mostly driven by banks from non-sanctioning jurisdictions (the grey bars), European and Japanese lenders started to increase their euro lending to Russia by the end of 2016 and account for the vast majority of the increase in euro lending by the end of 2018. Notice that even American banks choose to denominate their Russian claims in euro.

In summary, we show that, although global provision of credit to Russia substantially declined (Figure 1.3 and 1.5), banks that decided to remain active in the Russian markets denominated their claims in euros, rather than U.S. dollars. We show that a large share of the increase in euro lending comes from banks that did not have any euro exposure in Russia prior to 2014, and that the shift to euro claims occurs across non-sanctioning and sanctioning jurisdictions.

All in all, in line with Proposition 1, aggregate sanctioning coalition claims declined more than non-sanctioning coalition ones. Additionally, consistent with Proposition 2, our decomposition highlights how banks shifted to euro-denomination regardless of whether they were ultimately subject to a sanctioning jurisdiction or not. Recall from the firm-level evidence in Section 1.4 that euro-denominated lending was overwhelmingly directed to non-sanctioned firms after 2014. Our decomposition patterns are therefore consistent with banks previously accustomed to

⁵⁴To preserve anonymity, we must group extensive and intensive margin contributions, as well as suppress a small number of observations.

lending to Russia in U.S. dollars shifting their claims to an alternative denomination in response to an increase in the perceived sanction compliance risk of lending to non-sanctioned Russian firms, particularly in U.S. dollars.

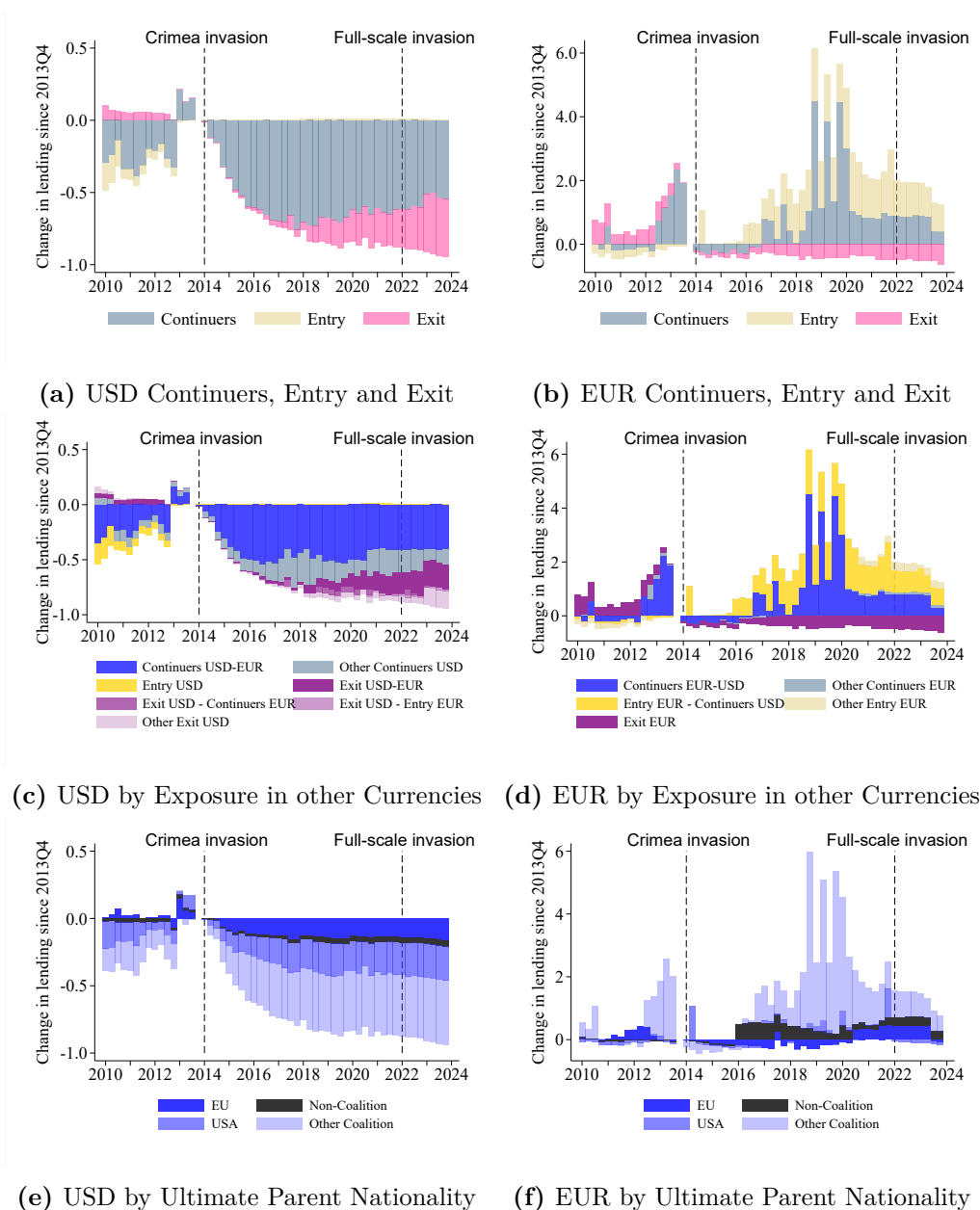


Figure 1.5: Margins Decomposition of Total Lending to Russia in USD and EUR

Note. – Bars within every quarter add up to the total change in lending to Russia for that currency with respect to 2013Q4. To preserve anonymity some observations have been suppressed, so totals might not exactly line up. In Panel (e) “Other Coalition” includes AUS, CAN, CHE, GBR, JPN, NOR; “Non-Coalition” includes ARE, BHR, CHN, EGY, KOR, IND, ISR, NGA, RUS, SGP, TUR, TWN, ZAF. In Panel (f) “Other Coalition” includes CAN, CHE, GBR, JPN; “Non-Coalition” includes BHR, CHN, KOR, NGA, RUS, TWN, ZAF.

Source: Bank of England’s dataset on claims of UK banks on non-residents.

1.5.3 A Bank-level Empirical Analysis of Sanction-risk Driven Jurisdiction and Currency Frictions

Jurisdiction and Currency Frictions in Global Credit to Russia

We now turn to an empirical exercise directly testing the relevance of jurisdiction and currency de-risking margins within banks. Recall that our bank-level data are representative of the universe of banks located in the UK, a sanctioning jurisdiction, where we are able to observe claims of branches or subsidiaries of foreign banks - on a nationality basis - booked from London. This nets out any difference in residence and allows us to focus on the de-risking margins driven by the ultimate-parent jurisdiction of the banks. The parents of those UK-resident banks are indeed ultimately based in both sanctioning and non-sanctioning jurisdictions.

As a baseline to test Proposition 1, i.e. whether banks from sanctioning-coalition jurisdictions reduce claims on Russia more than banks from non-coalition jurisdictions, we first estimate the following regression:

$$l_{bt}^{RUS} = \exp (\theta_1 \cdot \text{Coalition}_b \times \text{Post}_t + k + \varphi_b + \varphi_t) + \varepsilon_{bt} \quad (1.5.3.1)$$

where l_{bt}^{RUS} are claims on Russia for bank b in quarter t aggregated across all currencies. Post_t , is a dummy variable that is equal to 1 after and including Q1 2014, and Coalition_b is a dummy variable equal to 1 if the bank's ultimate parent is based in a country taking part in sectoral sanctions against Russia as described in Section 1.2.⁵⁵ In this specification, we control for bank and time fixed effects.

In order to study the currency de-risking margin we can then split banking claims by currency and estimate the following regression, as a direct test of Proposition 2, i.e. whether all banks, regardless of sanctioning status, reallocate claims

⁵⁵As a reminder, the coalition includes the U.S., all EU members, all EEA members, Canada, Australia, Switzerland and Japan.

away from the U.S. dollar towards non-U.S. dollar currencies:

$$\begin{aligned}
l_{bct}^{RUS} = & \exp (\gamma_1 \cdot \text{Coalition}_b \times \text{Post}_t \\
& + \gamma_2 \cdot \text{Currency}_c \times \text{Post}_t \\
& + \gamma_3 \cdot \text{Currency}_c \times \text{Post}_t \times \text{Coalition}_b \\
& + k + \varphi_{bc} + \varphi_t) + \varepsilon_{bct}
\end{aligned} \tag{1.5.3.2}$$

where l_{bct}^{RUS} are claims on Russia for bank b in quarter t and currency c , for which we observe claims in U.S. dollar, euro, pound sterling, Swiss franc, Japanese yen and a residual “Other” currencies. Currency_c is a currency dummy retaining the U.S. dollar as the base category. We consider two main cases: one where Currency_c contrasts the base category, the U.S. dollar, against the sum of non-USD currency claims, and another where Currency_c contrasts euro-denominated claims directly against U.S. dollar claims. In the appendix we include results for specifications where we also report separately euro, pound sterling, and Other-currency claims relative to the U.S. dollar.⁵⁶ The interactions in Equation 1.5.3.1 and 1.5.3.2 provide a direct test for our propositions in Section 1.2. First, a negative sanctioning-coalition jurisdiction interaction θ_1 would indicate that banks ultimately subject to a sanctioning jurisdiction decreased claims on Russia more, relative to banks whose parents are based in non-sanctioning jurisdictions (Proposition 1), regardless of the currency denomination of claims. Second, positive estimates for both the non-coalition banks’ non-USD relative to USD shift, γ_2 , and the corresponding coalition-bank shift, $\gamma_2 + \gamma_3$, would indicate that banks in both non-sanctioning and sanctioning jurisdictions increased claims in non-USD currencies relative to U.S. dollars, consistent with Proposition 2. The coefficient γ_3 then tests whether the strength of this currency shift differs between coalition and non-coalition banks.

By contrast, γ_1 and $\gamma_1 + \gamma_3$ compare coalition and non-coalition banks within USD and non-USD claims, respectively. These objects therefore speak to jurisdic-

⁵⁶We do not include the Swiss franc and Japanese yen in the split-currency specifications, as the variation of claims on Russia denominated in these currencies is too sparse given our fixed-effect structure.

tional differences in claims on Russia by currency component, rather than to the currency de-risking prediction itself.

To tighten identification, we expand the same logic to a panel of UK-resident banks' claims across all destination countries. We first study the jurisdictional margin for claims on Russia relative to other destinations using a bank-destination-quarter panel:

$$l_{bdt} = \exp (\tilde{\theta}_1 \cdot \text{Coalition}_b \times \text{Post}_t \times \text{Russia}_d \\ + k + \varphi_{bd} + \varphi_{bt} + \varphi_{dt}) + \varepsilon_{bdt} \quad (1.5.3.3)$$

In contrast, when studying currency-driven de-risking in Russia, on a bank, destination, currency and time panel, the expanded estimating equation reads:

$$l_{bcdt} = \exp (\tilde{\gamma}_1 \cdot \text{Coalition}_b \times \text{Post}_t \times \text{Russia}_d \\ + \tilde{\gamma}_2 \cdot \text{Currency}_c \times \text{Post}_t \times \text{Russia}_d \\ + \tilde{\gamma}_3 \cdot \text{Currency}_c \times \text{Post}_t \times \text{Coalition}_b \\ + \tilde{\gamma}_4 \cdot \text{Currency}_c \times \text{Post}_t \times \text{Coalition}_b \times \text{Russia}_d \\ + k + \varphi_{bcd} + \varphi_{bt} + \varphi_{ct} + \varphi_{dt}) + \varepsilon_{bcdt} \quad (1.5.3.4)$$

where the additional dimension, destination d , allows for a fourth interaction variable, Russia_d , i.e. a dummy equal to 1 for claims on Russia.

The interactions in Equation 1.5.3.4 are the all-destination analogues of those in Equation 1.5.3.2, but are interpreted as Russia-specific deviations relative to other destination countries and are denoted with tildes. The coefficient $\tilde{\gamma}_3$, on $\text{Currency}_c \times \text{Post}_t \times \text{Coalition}_b$, absorbs any post-2014 change in coalition banks' currency composition outside Russia. It is therefore included so that $\tilde{\gamma}_2$, $\tilde{\gamma}_4$, and the total effect $\tilde{\gamma}_2 + \tilde{\gamma}_4$ are interpreted as Russia-specific currency-margin effects, rather than as broader changes in coalition banks' global currency composition.

The fullest specification in this exercise includes bank-destination-currency, bank-time, currency-time, and destination-time fixed effects. Identification therefore

comes from changes within bank-destination-currency over time, net of bank-, destination-, and currency-specific time-varying factors.

All specifications are estimated by PPML on claim levels, allowing zero-valued claim observations. To retain both intensive-margin changes and entry or exit from positive lending positions, we fill missing quarters within the relevant observed panel cells or collapsed units and set missing claims to zero.

Table 1.3 and Table 1.4 report the main bank-level evidence on claims on Russia after the 2014 sectoral sanctions. They are organized to separate the estimated interaction terms from the economic objects used to test the propositions. Panel A reports the coefficients that enter the estimating equations directly, while Panels B and C reorganize those coefficients into intuitive margins: jurisdictional differences in total claims for Proposition 1, and within-bank-group currency shifts relative to USD for Proposition 2.

Some coefficients are repeated across panels because the same estimated object enters several economically distinct comparisons. For example, the USD coalition effect is both an estimated interaction term and one component of the coalition effect in non-USD or EUR claims; repeating it makes the decomposition transparent without implying that it is separately estimated each time.

What do the results say about margins of de-risking in Russia after 2014? The evidence in Panel B of Table 1.3 is supportive of our Proposition 1. In the Russia-only specification, the estimated coalition effect on total claims is negative, with a PPML log coefficient of -0.686 . Exponentiating this estimate implies that, after the 2014 sanctions, coalition banks reduced their total claims on Russia by about 50% more than non-coalition banks, across all currency denominations. This is consistent with a jurisdictional de-risking margin: banks whose ultimate parents are located in sanctioning jurisdictions contracted their Russia exposures more strongly than banks headquartered outside the sanctioning coalition.

The all-destination exercise in Panel B of Table 1.4 reinforces this interpretation. Column (1) compares claims on Russia with claims on other destinations and estimates a Russia-specific coalition effect of -0.409 . The implied magnitude is

Table 1.3: Bank Claims on Russia after the 2014 Sectoral Sanctions:
Jurisdictional and Currency Margins

	(1) Total Claims	(2) Non-USD vs. USD	(3) EUR vs. USD
Panel A. Estimated Interaction Terms			
Coalition $\times$ Post (θ_1)	-0.686* (0.416)		
Coalition $\times$ Post (γ_1)		-0.584** (0.289)	-0.584** (0.290)
Currency $\times$ Post (γ_2)		1.381** (0.680)	2.014*** (0.642)
Currency $\times$ Post $\times$ Coalition (γ_3)		-0.505 (0.710)	-0.739 (0.694)
Panel B. Jurisdictional Margin: Total Claims			
<i>Between:</i> Coalition Effect, Total Claims (θ_1)	-0.686* (0.416)		
Panel C. Currency Margin: Claims Relative to USD			
<i>Between:</i> Coalition Effect, USD Claims (γ_1)		-0.584** (0.289)	-0.584** (0.290)
<i>Within</i> Non-Coalition: Non-USD (EUR) Shift (γ_2)		1.381** (0.680)	2.014*** (0.642)
<i>Between:</i> Difference in Non-USD (EUR) Shift (γ_3)		-0.505 (0.710)	-0.739 (0.694)
<i>Within</i> Coalition: Non-USD (EUR) Shift ($\gamma_2 + \gamma_3$)		0.876*** (0.277)	1.275*** (0.349)
<i>Between:</i> Coalition Effect, Non-USD (EUR) Claims ($\gamma_1 + \gamma_3$)		-1.089 (0.850)	-1.323 (0.823)
Observations	6,716	10,412	7,967
Pseudo R2	0.844	0.804	0.790
Currency Definition	Collapsed	Non-USD vs. USD	EUR vs. USD
Bank FE	✓		
Bank-currency FE		✓	✓
Quarter FE	✓	✓	✓

Notes. The dependent variable is claims on Russia. Column (1) collapses claims across currencies to the bank-quarter level and estimates the coalition effect on total claims. Column (2) keeps the bank-currency-quarter panel and compares claims denominated in all non-USD currencies to claims denominated in USD. Column (3) keeps only USD and EUR claims and compares EUR-denominated claims to USD-denominated claims. Entries are PPML log coefficients or linear combinations of PPML log coefficients. Standard errors are clustered by bank and quarter. In the row labels, “Within” denotes currency-category shifts relative to USD within the indicated bank group, while “Between” denotes coalition versus non-coalition comparisons. “Non-USD (EUR)” means non-USD in column (2) and EUR in column (3). USD and non-coalition banks are the omitted categories. All specifications include the fixed effects reported at the bottom of the table. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 1.4: Bank Claims on Russia Relative to Other Destinations after the 2014 Sectoral Sanctions: Jurisdictional and Currency Margins

	(1) Total Claims	(2) Non-USD vs. USD	(3) EUR vs. USD
Panel A. Estimated Interaction Terms			
Coalition $\times$ Post $\times$ Russia ($\tilde{\theta}_1$)	-0.409*** (0.057)		
Coalition $\times$ Post $\times$ Russia ($\tilde{\gamma}_1$)		-0.326*** (0.104)	-0.222** (0.087)
Currency $\times$ Post $\times$ Russia ($\tilde{\gamma}_2$)		1.339*** (0.517)	1.790*** (0.566)
Currency $\times$ Post $\times$ Coalition ($\tilde{\gamma}_3$)		-0.312 (0.380)	-0.382 (0.401)
Currency $\times$ Post $\times$ Russia $\times$ Coalition ($\tilde{\gamma}_4$)		-0.491 (0.539)	-0.494 (0.593)
Panel B. Jurisdictional Margin: Total Claims			
<i>Between:</i> Coalition Effect, Total Claims ($\tilde{\theta}_1$)	-0.409*** (0.057)		
Panel C. Currency Margin: Claims Relative to USD			
<i>Between:</i> Coalition Effect, USD Claims ($\tilde{\gamma}_1$)		-0.326*** (0.104)	-0.222** (0.087)
<i>Within</i> Non-Coalition: Non-USD (EUR) Shift ($\tilde{\gamma}_2$)		1.339*** (0.517)	1.790*** (0.566)
<i>Between:</i> Difference in Non-USD (EUR) Shift ($\tilde{\gamma}_4$)		-0.491 (0.539)	-0.494 (0.593)
<i>Within</i> Coalition: Non-USD (EUR) Shift ($\tilde{\gamma}_2 + \tilde{\gamma}_4$)		0.847*** (0.075)	1.295*** (0.088)
<i>Between:</i> Coalition Effect, Non-USD (EUR) Claims ($\tilde{\gamma}_1 + \tilde{\gamma}_4$)		-0.818* (0.464)	-0.716 (0.544)
Observations	567,842	840,654	620,720
Pseudo R2	0.965	0.951	0.949
Currency Definition	Collapsed	Non-USD vs. USD	EUR vs. USD
Bank-destination FE	✓		
Bank-destination-currency FE		✓	✓
Bank-quarter FE	✓	✓	✓
Destination-quarter FE	✓	✓	✓
Currency-quarter FE		✓	✓

Notes. The dependent variable is bank claims by destination. Column (1) collapses claims across currencies to the bank-destination-quarter level. Columns (2) and (3) keep the bank-destination-currency-quarter panel and compare non-USD or EUR claims to USD claims. Entries are PPML log coefficients or linear combinations of PPML log coefficients. The coefficients in Panels B and C are Russia-specific effects relative to other destinations. In Panel A, Currency $\times$ Post $\times$ Coalition is reported because it is estimated in the all-destination currency regressions; Panel C focuses on Russia-specific margins and therefore uses the interactions with Russia. Standard errors are clustered by bank, destination, and quarter. In the row labels, “Within” denotes currency-category shifts relative to USD within the indicated bank group, while “Between” denotes coalition versus non-coalition comparisons. “Non-USD (EUR)” means non-USD in column (2) and EUR in column (3). USD and non-coalition banks are the omitted categories. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

a relative decline of about one third in coalition-bank claims on Russia, compared with non-coalition banks and relative to claims on other destinations. This more saturated specification therefore suggests that the Russia-only result is not merely capturing a general post-2014 contraction by coalition banks, but a Russia-specific reduction in claims by banks from sanctioning jurisdictions.

What about the currency-margin of adjustment to Russian sectoral sanctions? The results in Panel C of Table 1.3 support Proposition 2. In column (2), the row labelled *Within Non-Coalition: Non-USD (EUR) Shift* reports a coefficient of 1.381 for non-coalition banks. Exponentiating this estimate implies that, after the 2014 sanctions, non-USD claims on Russia relative to USD claims were approximately four times as large for non-coalition banks. The corresponding row for coalition banks, *Within Coalition: Non-USD (EUR) Shift*, reports a coefficient of 0.876, implying an increase of about 140 percent. Thus, both groups of banks shifted the currency composition of their Russia claims away from the U.S. dollar and toward non-USD currencies.

Column (3) shows that this currency shift is especially pronounced for the euro. The *Within Non-Coalition: Non-USD (EUR) Shift* row reports a coefficient of 2.014, implying that EUR claims relative to USD claims were about 7.5 times as large for non-coalition banks after the sanctions. The corresponding coalition-bank effect is 1.275, implying a little more than a 3.5-fold increase. These estimates indicate that the broad non-USD shift documented in column (2) is strongly reflected in a shift toward euro-denominated claims.

The row labelled *Between: Difference in Non-USD (EUR) Shift* is negative in both columns, but not statistically significant. This means that the estimates do not reject the null that coalition and non-coalition banks shifted away from USD by the same amount. In other words, the currency-composition response appears to be common across bank groups, rather than concentrated only among banks from sanctioning jurisdictions.

The all-destination exercise in Panel C of Table 1.4 reinforces the same conclusion. In column (2), non-USD claims on Russia relative to USD claims were

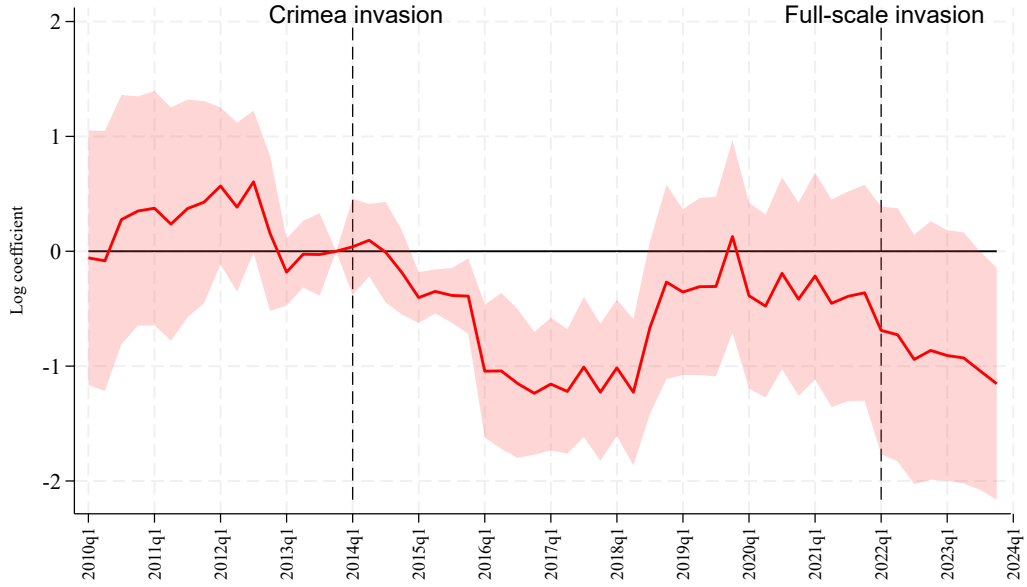
approximately four times as large for non-coalition banks, while the corresponding coalition-bank shift implies an increase of about 130%. In column (3), the EUR-relative-to-USD effects are again larger: about six times for non-coalition banks and about 3.5 times for coalition banks. As in the Russia-only table, the row labelled *Between: Difference in Non-USD (EUR) Shift* is not statistically significant. Hence, relative to claims on other destinations, claims on Russia show a clear post-sanctions shift away from USD and toward non-USD currencies, especially EUR, for both coalition and non-coalition banks.

To summarise, the overall reduction in claims on Russia is stronger for banks whose ultimate parents are located in sanctioning jurisdictions, consistent with Proposition 1. At the same time, the within-bank shift away from USD and toward non-USD currencies, especially the euro, appears across both coalition and non-coalition banks, with no statistically significant difference in the strength of this currency shift across jurisdictions. This is consistent with Proposition 2: U.S. extra-territorial jurisdiction raises dollar-related sanctions-compliance risk for banks globally, not only for banks headquartered in sanctioning jurisdictions.

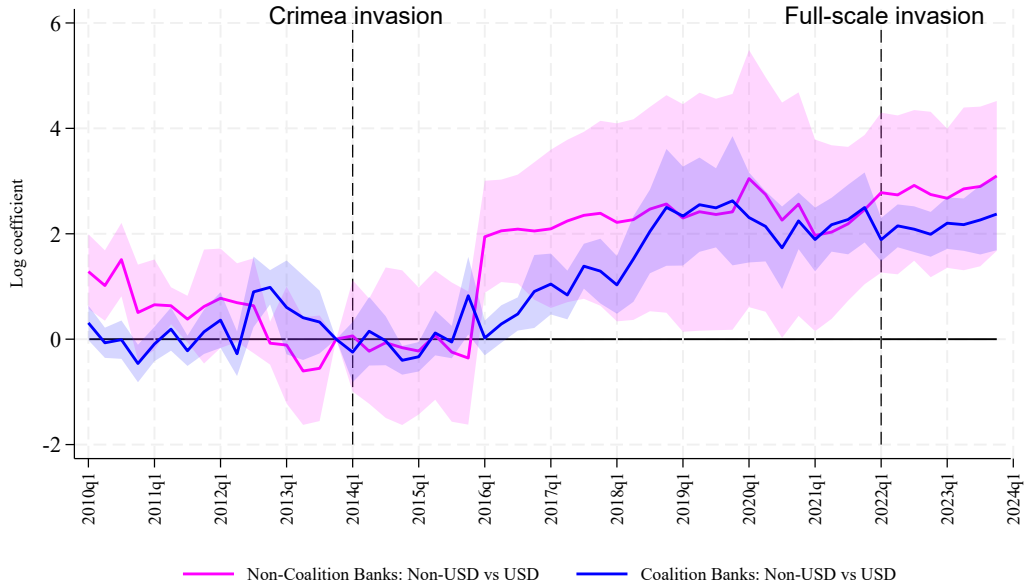
In the Appendix, we provide some further robustness to the above analysis. First, we split the non-USD currency margins in all estimable currency groups, clarifying whether other non-USD currencies behave similarly to the euro. We are unable to report claims in Swiss franc and Japanese yen in this exercise as they are too sparse within our fixed-effects, so the currency split is between EUR, GBP, the residual OTH category, likely to contain domestic currencies such as the ruble, and the base category, the U.S. dollar. Table A.9 shows that, in the Russia-only sample, the shift away from USD is driven primarily by euro-denominated claims. Both non-coalition and coalition banks increase EUR claims relative to USD claims after the sanctions, while the evidence for GBP is weaker and the residual Other-currency category is less systematic. Table A.11 reaches a similar conclusion in the all-destination specification: the EUR margin is the largest and cleanest component of the broader non-USD shift, with some positive evidence for GBP and OTH but smaller and less consistent across specifications. The remaining evidence presented

Figure 1.6: Bank Claims on Russia after the 2014 Sectoral Sanctions: Dynamic Effects

(a) Jurisdictional Margin: Total Claims



(b) Currency Margin: Non-USD Claims Relative to USD



Notes. Panel A plots the dynamic analogue of the jurisdictional-margin coefficient θ_1 , which is reported in column (1) of Table 1.3. The series is labelled as the coalition effect on total claims and measures the difference in claims on Russia between coalition and non-coalition banks in each quarter, relative to the omitted base period. Panel B plots the dynamic analogues of the currency-margin coefficients reported in column (2) of Table 1.3. The series labelled “Within Non-Coalition: Non-USD Shift” corresponds to γ_{2t} , the quarter-specific shift in non-USD claims relative to USD claims among non-coalition banks. The series labelled “Within Coalition: Non-USD Shift” corresponds to $\gamma_{2t} + \gamma_{3t}$, the corresponding shift among coalition banks. Coefficients are PPML log-point estimates; shaded areas report confidence intervals. The vertical lines mark the 2014 sectoral sanctions and the 2022 invasion of Ukraine.

Source: Bank of England’s dataset on claims of UK banks on non-residents.

in Appendix Tables A.8 and A.10 show that the currency-margin results are robust to alternative fixed-effect structures in both the Russia-only and all-destination specifications. The positive shift from USD toward non-USD claims, especially EUR, persists across these variants.

What about the dynamics of the jurisdictional and currency margins documented above? Figure 1.6 reports the dynamic analogues of the main Russia-only estimates in Table 1.3. Panel A plots the time-varying version of the jurisdictional-margin coefficient θ_1 , labelled as the coalition effect on total claims. Panel B plots the dynamic currency-margin effects corresponding to column (2) of Table 1.3: the *Within Non-Coalition: Non-USD Shift*, γ_{2t} , and the *Within Coalition: Non-USD Shift*, $\gamma_{2t} + \gamma_{3t}$.

First, notice how there is no evidence of pre-trends in either of our main channels of interest, which is consistent with coordination on EU-U.S. sectoral sanctions remaining uncertain until the diplomatic agreement reached in July 2014.

Second, the figure shows that the timing of the two margins differs. The jurisdictional de-risking margin in Panel A emerges earlier: coalition banks begin to reduce claims on Russia relative to non-coalition banks shortly after the 2014 sanctions, with the differential becoming most pronounced in the following years. The effect then partially reverses and is less precisely estimated before 2022, although the coefficient turns down again after the full-scale invasion. One interpretation of the partial reversal in Panel A is that coalition banks gradually resumed some Russia lending, but did so through a different composition of claims - for example more non-USD lending, different borrowers, or exposures less directly affected by the initial sectoral sanctions. By contrast, the currency margin in Panel B appears later, around late 2015 and early 2016, but is highly persistent once it emerges: both coalition and non-coalition banks shift Russia claims away from USD and towards non-USD currencies.

The later emergence of the currency margin raises a natural question about transmission. One possibility is that currency substitution requires new lending, i.e. refinancing needs kick in: the dollar-to-non-dollar margin could only become

visible once Russian borrowers returned to international credit markets and new claims were originated or rolled over (see Section 1.2). Another possibility is that Russian demand-side policies and borrower preferences also encouraged de-dollarisation. These channels are not mutually exclusive. Both are consistent with the currency-specific friction emphasised in Section 1.2: sanctions-compliance and settlement risk can matter to borrowers as well as lenders.

The next subsection therefore asks whether similar currency and jurisdictional margins appear outside Russia, where Russian de-dollarisation policies cannot directly explain the results. We adapt the bank-level specifications to non-Russia emerging-market destinations and examine whether banks exposed to Russia at the time of the Crimea invasion subsequently adjust their lending and currency composition elsewhere. This spillover exercise helps isolate the role of banks' own sanctions-compliance risk perceptions from Russia-specific borrower-side responses.

Sanction Risk Spillovers on Total and USD Denominated Claims on other Emerging Markets

We now ask whether the 2014 Russia sanctions affected banks' lending outside Russia, i.e. whether banks internalised sanction compliance risk along either the jurisdiction or currency margins, specifically for destinations that were more likely to be sanctioned in the future. The first exercise we provide excludes Russia from the estimating sample and tests whether banks more directly exposed to Russia, especially banks headquartered in sanctioning-coalition jurisdictions, subsequently adjusted their claims to other destinations. The dependent variable collapses claims across currencies, so this first specification speaks to total lending rather than currency composition. We estimate the following PPML specification:

$$l_{bdt} = \exp(\theta_1^S \cdot \text{BankGroup}_b \times \text{Post}_t \times \text{Destination}_d + k + \varphi_{bd} + \varphi_{bt} + \varphi_{dt}) + \varepsilon_{bdt} \quad (1.5.3.5)$$

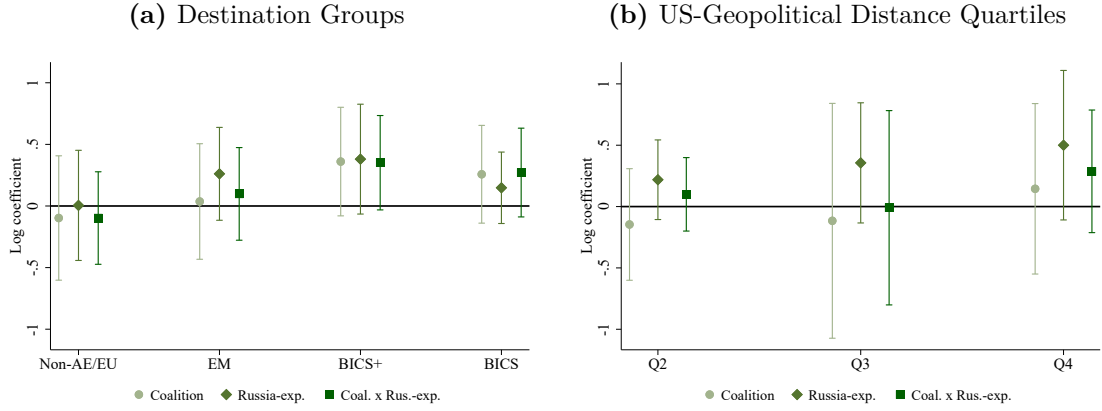
where l_{bdt} denotes total claims by bank b on non-Russia destination d in quarter t , collapsed across currencies. The sample excludes Russia. BankGroup_b is defined in turn as: banks headquartered in sanctioning-coalition jurisdictions; banks with

positive Russia claims in 2013Q4; and banks satisfying both conditions, $\text{Coalition}_b \times \text{Russia Position}_b^{2013Q4}$. Our preferred spillover treatment is the last group, which captures banks both exposed to Russia at the time of the Crimea invasion and headquartered in jurisdictions directly participating in the sanctions coalition. The coefficient θ_1^S captures whether the relevant bank group changed total claims to destination d after the 2014 sanctions, relative to banks outside that group. The fixed effects are bank-destination, bank-quarter, and destination-quarter fixed effects, and standard errors are clustered by bank, destination, and quarter. We vary Destination_d to capture destinations with different forward-looking geopolitical risk. We first use broad destination groups, including non-Russia countries outside advanced economies and the EU, emerging-market destinations, the original BICS countries excluding Russia, and a broader BICS+ group that includes all countries that had joined BRICS by 2025.⁵⁷ The BICS and BICS+ groups are useful proxies for destinations potentially perceived as more geopolitically exposed after the Russia sanctions. We complement these groupings with quartiles of geopolitical distance from the United States, based on UN ideal-point distance measures from Bailey et al. (2017) fixed at 2000-2013. In those specifications, the first quartile interaction is omitted, and the reported coefficients compare destinations in quartiles 2, 3 and 4 with the omitted reference group, i.e. the “Western bloc” more closely aligned with the United States. Table A.12 shows the intersection of the BRICS+ group with geopolitical distance quartiles over 2000-2013.

Figure 1.7 plots the estimated θ_1^S coefficients from Equation 1.5.3.5. Panel (a) reports estimates for the destination-group specifications, while Panel (b) reports estimates for geopolitical-distance quartiles, with Q1 omitted. The three series correspond to the three alternative definitions of BankGroup_b : coalition banks, Russia-exposed banks, and coalition $\times$ Russia-exposed banks. The full regression results underlying the figure are reported in Appendix Tables A.13, A.14, and A.15, respectively.

⁵⁷Including, on top of the original group, Egypt, Ethiopia, Iran, the UAE and Indonesia.

Figure 1.7: Jurisdiction and Russia-Exposure Spillovers to Total Claims



Notes. The figure reports PPML log coefficients from the total-claims spillover specification. The dependent variable is bank claims to non-Russia destinations, collapsed across currencies to the bank-destination-quarter level. Panel (a) reports coefficients for destination groups: all non-advanced-economy/non-EU destinations, emerging-market destinations, BICS+, and the original BICS countries excluding Russia. Panel (b) reports coefficients for quartiles of geopolitical distance from the United States based on UN ideal-point distance from Bailey et al. (2017); Q1 is the omitted reference quartile. “Russia-exposed” denotes banks with positive Russia claims in 2013Q4. “Coalition $\times$ Russia-exposed” denotes Russia-exposed banks whose ultimate parent is headquartered in a sanctioning-coalition jurisdiction. All specifications exclude Russia and include bank-destination, bank-quarter, and destination-quarter fixed effects. Standard errors are clustered by bank, destination, and quarter. Vertical bars report 95 percent confidence intervals.

Source: Bank of England’s dataset on claims of UK banks on non-residents.

The figure shows little evidence that the Russia shock generated spillovers in total claims to non-Russia destinations. Across both the destination-group specifications and the geopolitical-distance quartiles, the estimated coefficients are generally imprecise and do not indicate a systematic change in lending by coalition, Russia-exposed, or coalition $\times$ Russia-exposed banks.

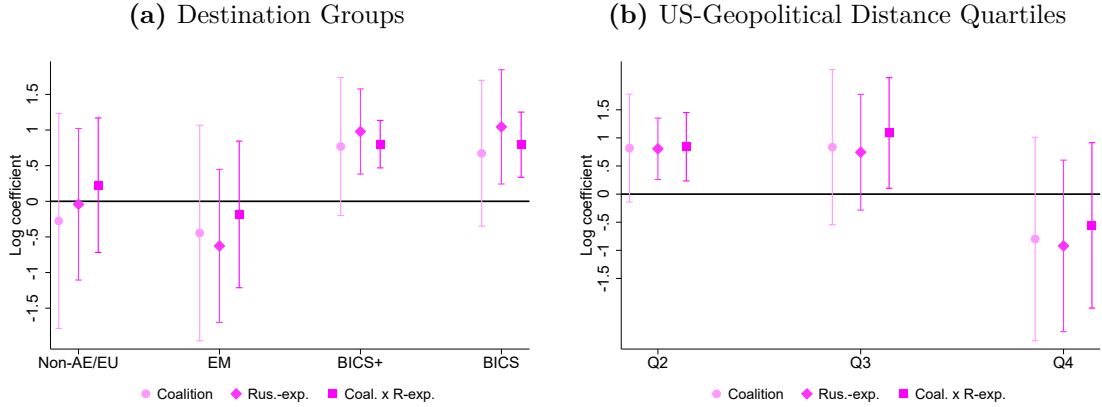
What about spillovers on the currency de-risking margin? To investigate this, we turn to a currency-level specification that mirrors Equation 1.5.3.5, but keeps the currency denomination of claims instead of collapsing claims across currencies. This allows us to test whether banks exposed to Russia, especially those headquartered in sanctioning-coalition jurisdictions, shifted claims to non-Russia destinations away from USD and toward EUR after the 2014 sanctions. We estimate the following

PPML specification:

$$\begin{aligned}
l_{bcdt} = & \exp (\gamma_1^S \cdot \text{BankGroup}_b \times \text{Post}_t \times \text{Destination}_d \\
& + \gamma_2^S \cdot \text{Currency}_c \times \text{Post}_t \times \text{Destination}_d \\
& + \gamma_3^S \cdot \text{Currency}_c \times \text{Post}_t \times \text{Destination}_d \times \text{BankGroup}_b \\
& + k + \varphi_{bcd} + \varphi_{bt} + \varphi_{dt} + \varphi_{ct}) + \varepsilon_{bcdt}
\end{aligned} \tag{1.5.3.6}$$

where l_{bcdt} denotes claims by bank b on non-Russia destination d in currency c and quarter t . The sample excludes Russia and keeps USD and EUR claims. Currency_c is equal to one for EUR-denominated claims, with USD as the omitted category. The fixed effects are bank-destination-currency, bank-quarter, destination-quarter, and currency-quarter fixed effects.

Figure 1.8: De-Dollarisation Spillovers by Jurisdiction and Russia Exposure



Notes. The figure plots the coefficient γ_3^S from Equation 1.5.3.6, corresponding to $\text{EUR} \times \text{Post} \times \text{Destination} \times \text{BankGroup}$. This coefficient measures the additional post-2014 EUR-vs-USD shift of the indicated bank group relative to banks outside that group. BankGroup is defined in turn as coalition banks, Russia-exposed banks, and coalition $\times$ Russia-exposed banks. Panel (a) reports destination-group interactions. Panel (b) reports geopolitical-distance quartile interactions, with Q1 omitted. The sample excludes Russia and keeps USD and EUR claims. Vertical bars report 95 percent confidence intervals. Standard errors are clustered by bank, destination, and quarter.

Source: Bank of England's dataset on claims of UK banks on non-residents.

Having shown above that claims on Russia shifted away from USD and toward EUR after the 2014 sanctions, we therefore now ask whether the same banks adjusted the currency denomination of claims to non-Russia destinations. The results are strongly suggestive of de-dollarisation spillovers to jurisdictions less aligned with the West, plausibly driven by banks' exposure to the Russian 2014 sectoral

sanctions shock. Figure 1.8 plots the differential EUR-vs-USD response, γ_3^S , while Appendix Tables A.16, A.17, and A.18 report the full estimates. The strongest pattern is not for coalition banks in general, but for banks with pre-existing Russia exposure, especially in the BICS and BICS+ destination groups. Banks that were both Russia-exposed and headquartered in coalition jurisdictions, the differential EUR-vs-USD shift is about $e^{0.80} - 1 \simeq 120\%$ for BICS/BICS+ destinations.

The geography of the effect is revealing. BICS and BICS+ are groups that over the last decade have become loosely institutionalised as a relatively explicitly non-Western bloc. The geopolitical-distance quartiles point in the same direction but are noisier. Q4 includes countries far from the U.S. in UN-voting space, but it is economically heterogeneous, including U.S. allies, very poor countries, and already heavily sanctioned economies. Q2 and Q3 are therefore also informative: many countries in those quartiles are not especially aligned with the U.S., and Russia itself falls in Q2 in the classification reported in Appendix Table A.12. For coalition $\times$ Russia-exposed banks, the differential EUR-vs-USD response is about $e^{0.84} - 1 \simeq 130\%$ in Q2 and about $e^{1.09} - 1 \simeq 200\%$ in Q3, relative to banks that were not both coalition and Russia-exposed. The corresponding Q4 estimate is negative and statistically insignificant, consistent with the greater heterogeneity of that quartile. Coalition $\times$ Russia-exposed banks therefore increased the EUR denomination of claims relative to USD substantially more in Q2 and Q3 destinations after 2014. The Appendix tables A.16, A.17 and A.18, also report two linear combinations that help interpret the plotted differential effects. First, $\gamma_2^S + \gamma_3^S$ measures the EUR-vs-USD shift within the treated bank group itself: that is, whether Russia-exposed banks, or coalition $\times$ Russia-exposed banks, increased EUR-denominated claims relative to USD-denominated claims after 2014. This effect is positive across most destination definitions. Second, $\gamma_1^S + \gamma_3^S$ measures the treated bank group's relative effect on EUR claims, compared with banks outside the treated group. This effect is positive for BICS/BICS+ and some distance quartiles, suggesting that the spillover is not only a relative fall in USD claims but also, in those destinations, a relative strengthening of EUR-denominated claims.

Taken together, the bank-level evidence presented in this Section has shown that the 2014 sectoral sanctions generated both jurisdictional and currency-margin responses. However, the currency margin de-dollarisation clearly emerges as the starkest and more persistent adjustment. Claims on Russia shifted away from the U.S. dollar and toward the euro, and the same de-dollarisation margin appears in non-Russia emerging-markets destinations for banks most exposed to the Russia shock. These results establish that sanction risk can alter the usage of the U.S. dollar in global financial flows. This points to a higher level of substitutability of the dominant currency than suggested in the literature, which has long emphasised the inertia in international currency equilibria, driven by network effects (Gopinath and Itskhoki, 2022). We now turn to an analysis of joint quantity and price movements in the Russian syndicated loans market, which will provide a quantification of substitutability of the U.S. dollar as a vehicle currency.

1.6 Evidence on Prices and Quantities from the Russian Syndicated Loans Market

In this section we study a sample of large cross-border loans to Russia for which we can observe both prices and quantities, relying on the universe of DealScan syndicated loans. We jointly examine the shift in prices and quantities along jurisdiction and currency-specific margins for loans subject to high levels of sanction-compliance risk, which complements the evidence presented so far in two ways. First, it can help disentangle demand and supply effects in credit markets subject to sanction compliance risk. Second, demand elasticity and substitutability are at the core of theoretical models of geoeconomic power (Clayton, Maggiori et al., 2025a; Clayton, Maggiori et al., 2025b): this is where loans data on the volume and prices of cross-border flows to Russia are highly complementary to the stock of cross-border claims studied in Section 1.5.

1.6.1 Stylised Facts

We begin with documenting stylised facts on the change in the volume of syndicated loans originated to Russian borrowers, and their corresponding prices, around the 2014 invasion of Crimea and subsequent imposition of international sanctions. We focus on whether we can detect any differential patterns along the usual jurisdiction and currency margins, namely sanctioning banks vs non-sanctioning coalition banks as well as U.S. dollar vs. non-dollar loans. Our variables of interest (See Section 1.3 for more details on the sample of DealScan loans we observe) are aggregated at the borrower-lender-year or borrower-lender-currency-year level. At the highest level of disaggregation of our estimating dataset, we can therefore observe the annual loan volume provided by the same lender to the same borrower in the same currency in any given year, and, where available, its volume-weighted average price counterpart.

Figure 1.9 reports both variables split by whether the originating bank was ultimately headquartered in a sanctioning jurisdiction or not.⁵⁸ As expected, the panel

⁵⁸The definition of sanctioning jurisdiction is the same as in Section 1.5. It comprises banks whose ultimate parent is based in the U.S., EU members and EEA associated countries, Australia, Canada, Switzerland and Japan.

on the left shows that annual lending volumes to Russia increased after 2014 for non-sanctioning coalition banks, while the distribution of lending volumes became more concentrated around the pre-Crimea median for sanctioning coalition banks. The median value-weighted spread applied to Russian loans by non-sanctioning coalition banks increased by about 50bp, while the one applied by sanctioning coalition banks remained constant.

Figure 1.10 reports the equivalent charts looking along the currency split of Russian syndicated loans volumes and prices. We note two main points. On the one hand, the panel on the left shows that euro yearly lending volumes increased markedly relative to dollar loan volumes.⁵⁹ Importantly, the volume-weighted median spread applied to euro loans *declined* after 2014, while dollar median spreads slightly increased.

Of course, to give any economic interpretation to the raw data patterns, one needs to disentangle composition effects along all the key dimensions of interest. Similarly to the previous section we therefore now proceed to disentangle the shift due to jurisdiction and currency frictions relying on interactions and a rich set of fixed-effects, looking at both loan volumes and prices.

1.6.2 Disentangling Jurisdiction and Currency Margins in Loan Prices and Quantities

An important challenge to identifying the differential credit supply response to financial sanctions is that borrower characteristics may vary across Russian and non-Russian firms, and sanction risk may also affect borrower credit demand. The same concern arises when studying the currency denomination of loans to Russian borrowers, since currency choice may reflect borrower hedging motives, trade invoicing, or balance-sheet exposures rather than lender supply.⁶⁰ Our fixed-effect structure is designed to absorb these borrower-level demand drivers by com-

⁵⁹Figure A.12 in the appendix shows that rouble yearly lending volumes also increased markedly relative to dollar loan volumes. We barely observe any prices for rouble loans in DealScan after 2014, so we are unable to analyse the shift in prices for rouble syndicated loans.

⁶⁰For example, sales and their geographical distribution have been shown to be associated with the currency denomination of debt among large firms in developed countries (Colacito et al., 2021).

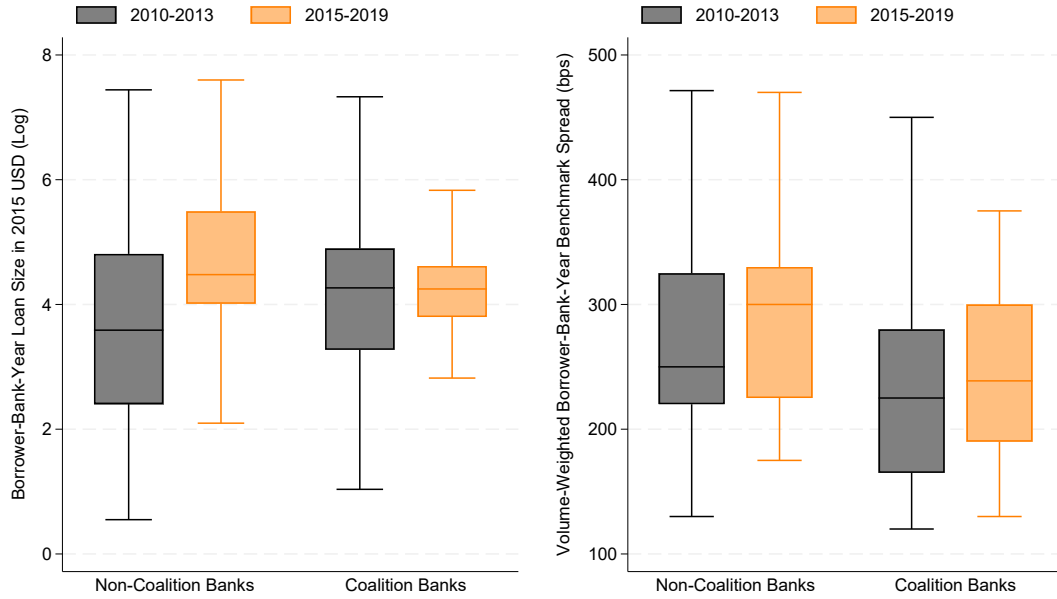


Figure 1.9: Russian Syndicated Loans Size and Spread by Bank Jurisdiction Before and After 2014.

Note. – Averaged loan size and spread for bank-borrower-currency-year observations on the universe of Russian syndicated loans. Coalition banks are banks whose ultimate parent is based in a sanctioning coalition country. Loan size is computed from the US dollar converted tranche amount deflated to 2015 US prices. Spreads refer to the all-in drawn spread over the benchmark free rate.

Source: DealScan and authors' calculations.

paring lending across lenders and currencies within the same borrower-year. As highlighted by Elliott, Meisenzahl and Peydró (2024) in the context of banks and non-banks, two features of the syndicated lending market further help isolate the lender-side response. First, syndicated loans involve multiple lenders to the same borrower, allowing us to compare how different institutions lend to the same firm. Second, while the borrower selects the lead arranger, other syndicate participants are typically assembled through a book-building process managed by the arranger, limiting direct borrower control over the identity of participant lenders. Finally, because syndicated-loan prices are quoted as spreads over benchmark rates, spread regressions remove much of the mechanical pricing difference associated with different money-market paths across currencies.

We begin by studying the lender-jurisdiction margin: whether, after the 2014 sectoral sanctions, coalition and non-coalition lenders differentially changed the

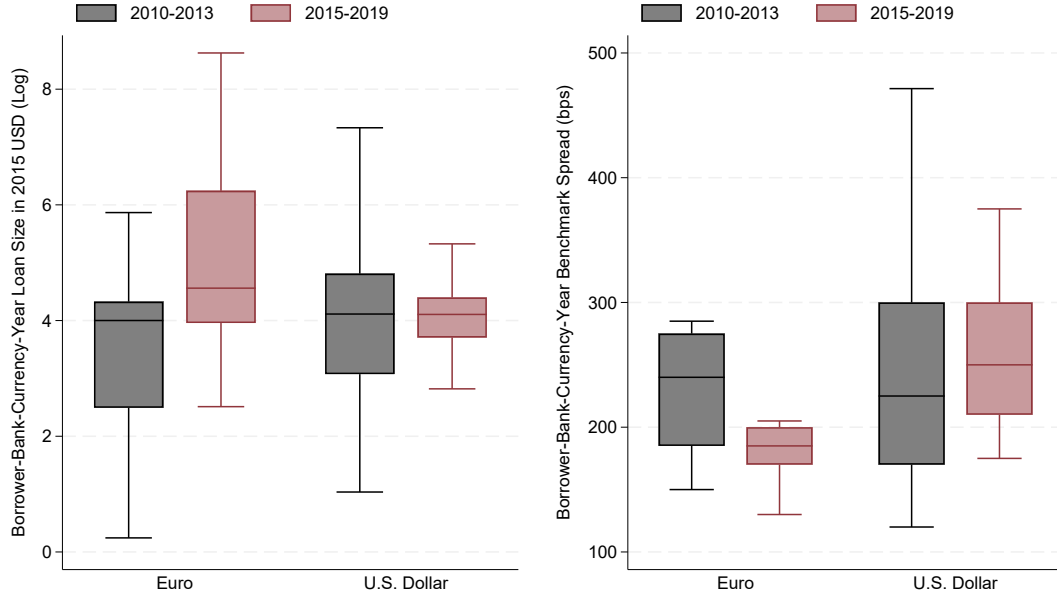


Figure 1.10: Russian Syndicated Loans Size and Spread by Currency Before and After 2014.

Note. – Averaged loan size and spread for bank-borrower-currency-year observations on the universe of Russian syndicated loans. Loan size is computed from the US dollar converted tranche amount deflated to 2015 US prices. Spreads refer to the all-in drawn spread over the benchmark free rate.

Source: DealScan and authors' calculations.

quantity and price of syndicated credit supplied to Russian borrowers. The baseline specification is estimated on a borrower-lender-year panel of Russian and other emerging-market borrowers, aggregating loan volumes across currencies. The estimating equation reads:

$$\begin{aligned}
 Y_{blt} = & \beta_1 \cdot Post_t \times Coalition_l \times Russia_b \\
 & + \beta_2 \cdot Coalition_l \times Russia_b \\
 & + k + \varphi_{bt} + \varphi_{lt} + \varepsilon_{blt}
 \end{aligned} \tag{1.6.2.1}$$

where the dependent variable is either annual syndicated-loan volume or the volume-weighted benchmark spread on priced syndicated credit extended by lender l to borrower b and originating in year t . The dummy $Post_t$ equals one from 2015 onward, with 2014 excluded from the estimation sample.⁶¹ $Coalition_l$ equals one

⁶¹We exclude 2014 from the estimation sample because sanctions were introduced during the

when the country of the lender’s ultimate parent is part of the sanctioning coalition, and $Russia_b$ identifies Russian borrowers. We include borrower-year fixed effects, φ_{bt} , and lender-year fixed effects, φ_{lt} . The borrower-year fixed effects absorb time-varying borrower credit demand, including borrower-specific exposure to sanctions, while the lender-year fixed effects absorb time-varying lender supply shocks common across borrowers. Level quantity specifications are estimated by PPML to retain zero lending observations. Log quantity specifications are estimated by OLS on positive lending observations, while spread and log-spread specifications are estimated by OLS on observations with observed benchmark spreads.

The coefficient of interest is β_1 . It measures whether, after sanctions, coalition lenders changed their lending to Russian borrowers differently from non-coalition lenders, relative to the corresponding difference for non-Russian emerging-market borrowers. In the price specifications, a positive β_1 would indicate that coalition lenders require a higher spread to lend to Russian borrowers after sanctions, consistent with a sanction-compliance or enforcement-risk premium. In the quantity specifications, a negative β_1 indicates that coalition lenders reduce lending to Russian borrowers relative to non-coalition lenders, consistent with substitution away from sanctioning-jurisdiction lenders.

We then turn to vehicle-currency substitution — the key margin of substitution highlighted in Section 1.5. We restrict attention to syndicated credit denominated in either U.S. dollars or euros, and estimate the following specification on a borrower-lender-currency-year panel:

$$\begin{aligned}
Y_{blct} = & \beta_1 \cdot Post_t \times EUR_c \times Russia_b \\
& + \beta_2 \cdot EUR_c \times Russia_b \\
& + k + \varphi_{bt} + \varphi_{lt} + \varepsilon_{blct}
\end{aligned} \tag{1.6.2.2}$$

year: Russia’s invasion of Crimea occurred in February, while the main U.S. and EU sectoral sanctions were agreed and implemented only later in 2014. Since DealScan announcement dates do not always identify when the relevant lending decision was made, excluding 2014 avoids assigning transition-year loans mechanically to either the pre- or post-sanction regime.

where the dependent variable is either annual syndicated-loan volume or the volume-weighted benchmark spread on priced syndicated credit extended by lender l to borrower b , denominated in currency c , and originating in year t . The dummy EUR_c equals one for euro-denominated credit, with U.S. dollar-denominated credit as the omitted currency category. We include borrower-year fixed effects, φ_{bt} , and lender-currency-year fixed effects, φ_{lct} . Borrower-year fixed effects absorb borrower demand and borrower-specific sanction exposure in each year, while lender-currency-year fixed effects absorb lender-specific supply shocks within each currency-year. For the level quantity specification, the estimating sample is an active-relationship USD/EUR currency-choice panel: borrower-lender relationships are retained when they are active in at least one of the two vehicle currencies, so that zero lending in one currency is interpreted relative to an active lending relationship in the other. Log quantity specifications condition on positive lending, while price specifications condition on observed benchmark spreads. In quantity specifications, β_1 measures whether, after sanctions, Russian borrowers shift syndicated borrowing toward euros relative to U.S. dollars, compared with the corresponding currency shift among non-Russian emerging-market borrowers. In price specifications, β_1 measures the analogous post-sanctions change in the euro-dollar spread differential for Russian borrowers relative to non-Russian emerging-market borrowers. A negative coefficient in the spread regressions is consistent with an increase in the cost of dollar credit intermediation - as again prices are measured as spread over the risk-free rate - relative to the euro, which we would interpret as evidence of a sanction-risk related dollar settlement-risk premium.

The quantity and price coefficients can also be combined to summarize the degree of euro-dollar substitutability in syndicated lending, i.e. the relative response of quantity and prices. Because benchmark spreads are observed only for a subset of loans, we compute this reduced-form elasticity using specifications in which both the log quantity response and the log spread response are estimated on the same set of borrower-lender-currency-year observations with observed spreads. This ensures that the elasticity does not combine a quantity response estimated on

the broader lending panel with a price response estimated on the smaller priced-loan sample. The resulting elasticity scales the post-sanctions shift in euro-denominated loan volumes relative to U.S. dollar loan volumes by the corresponding change in the euro-dollar spread differential. It therefore summarizes how strongly Russian borrowers substitute towards euro-denominated syndicated credit when U.S. dollar credit becomes relatively more expensive.

1.6.3 Prices, Quantities and the Substitutability of Vehicle Currencies in International Credit Flows

Table 1.5 reports our baseline results, bringing together the lender-jurisdiction and vehicle-currency margins in a single table. Panel A focuses on lender-jurisdiction substitution by reporting the coefficient on $Post \times Russia \times Coalition$ from Equation (1.6.2.1). Panel B.1 focuses on vehicle-currency substitution by reporting the coefficient on $Post \times Russia \times EUR$ from Equation (1.6.2.2). In each panel, columns (1) and (2) report the main quantity specifications: a level-volume PPML specification that retains zero lending observations, and a log-volume OLS specification estimated on positive lending observations. Columns (3)-(6) restrict attention to observations for which benchmark spreads are reported. Columns (3) and (4) re-estimate the quantity response on this same set of priced observations, while columns (5) and (6) report the corresponding level-spread and log-spread responses. This common priced-loan sample is what allows us to compare quantity and price responses directly and to construct the reduced-form EUR-USD elasticity reported in Panel B.2.⁶²

Panel A asks whether Russian borrowers, which in our loan sample are overwhelmingly non-sanctioned⁶³, are able to replace credit from sanctioning-coalition lenders with credit from non-coalition lenders after sanctions. The evidence is limited. Column (1) shows a large and statistically significant decline in lending by

⁶²Our results don't suggest the equivalent response ratio for sanctioning jurisdiction-lender substitutability is a meaningful object to compute.

⁶³There are a low single digit number of syndicated loan deals to sectoral sanctioned firm, none of them priced, which prevent us from exploring sanctioned status heterogeneity in any meaningful way. Sanctioned-status is in any case absorbed by borrower-time fixed effects.

coalition lenders to Russian borrowers relative to non-coalition lenders in the broad quantity sample. This points to coalition-lender retrenchment on the extensive margin. Beyond this broad quantity response, however, the lender-jurisdiction margin is muted. The log quantity coefficient in column (2) is small and insignificant, and in the priced-loan sample the quantity and spread coefficients are also statistically indistinguishable from zero. In other words, we find evidence that coalition lenders reduce exposure to Russian borrowers, but little evidence that non-coalition lenders are able to replace them within syndicated lending, or that remaining coalition lenders charge a clear sanction-compliance cost related price premium.

Panel B shows a much stronger substitution pattern along the vehicle-currency margin. The coefficient on $Post \times Russia \times EUR$ is positive and statistically significant across all quantity specifications: after sanctions, Russian borrowers receive more syndicated credit in euros relative to U.S. dollars, compared with the corresponding currency shift among other emerging-market borrowers. At the same time, the spread coefficients are negative and statistically significant: euro-denominated loans become cheaper relative to dollar-denominated loans for Russian borrowers.

This joint quantity-price pattern is consistent with a dollar-specific sanction compliance cost, worth about 55bp. In particular, it can be interpreted as sanction-related settlement risk in U.S. dollar clearing, given how sanction compliance risk is internalised by dollar correspondent banks (see Section 1.2 and Matvos and Neiman (2026)). Two clarifications are important. First, we do not identify this effect from lending to directly sanctioned firms. Loans to sanctioned firms in our syndicated-loan data are close to non-existent and none of those that exist is priced. Second, we do not make the baseline specification fully interactive in lender jurisdiction and currency as we were able to do in Section 1.5. Variation in jurisdiction across currencies is simply too sparse for this to be feasible in the loan-level analysis. Nonetheless, our loan-level results confirm that the currency margin response dominate over the jurisdiction one following the 2014 sectoral sanctions on Russia. The joint quantity and price responses can be used to construct a

reduced-form measure of supply-side substitutability between the euro and the dollar as vehicle currencies for cross-border lending. Columns (3)-(6) in Table 1.5 estimate these quantity and price responses on the same set of loans with reported benchmark spreads, so the elasticity does not combine a broad quantity estimate with a narrower price sample. In column (4), the log quantity coefficient implies that euro lending rises by 0.663 log points relative to dollar lending, or about 94 percent. In column (6), the log spread coefficient implies that euro spreads fall by 0.210 log points relative to dollar spreads, corresponding to an approximately 19 percent decline in the euro-dollar spread ratio. Dividing these two log responses gives a reduced-form elasticity of about 3.16.

$$\hat{\sigma}_{EUR/USD} \equiv \frac{d(\log L^{EUR} - \log L^{USD})}{d(\log i^{EUR} - \log i^{USD})} \approx \frac{\hat{\beta}_Q^{\log}}{|\hat{\beta}_P^{\log}|} = \frac{0.663}{0.210} \approx 3.16. \quad (1.6.3.1)$$

This estimate is not the same object as the broad elasticity of substitution across all foreign financial-service suppliers. It is narrower, but especially relevant for geoeconomic power exercised through financial chokepoints such as the dollar clearing system: it measures substitution between vehicle currencies when the use of sanctions raises the relative risk of dollar-denominated intermediation. In this sense, it provides a direct empirical counterpart to the elasticity that disciplines how costly it is for targeted borrowers to move away from the sanctioned currency circuit. This is closely related to the substitution elasticity in the geoeconomic-power framework of Clayton, Maggiori et al. (2025b), where the ability to substitute away from a sanctioned foreign financial input governs the curvature of the target economy’s outside option. While Clayton, Maggiori et al. (2025b) calibrate their elasticity parameter, setting $\sigma_F = 1.8$ based on trade-cost estimates for financial services in Rouzet et al. (2017), our setting estimates the corresponding currency-substitution margin directly from the observed quantity and price response to financial sanctions, i.e. the usage of geoeconomic power by an hegemon.⁶⁴ Because

⁶⁴Our reduced-form elasticity captures only the substitution induced by the currency-specific friction we study - U.S. dollar settlement risk - and not the full set of channels through which sanctions could affect substitutability across financial-service providers more broadly. If instead computed with respect to the level of the financing-cost differential, $d(\log(1 + i^{EUR}) - \log(1 +$

the estimated changes are large, Panel B.2 also reports a finite-change version of the same calculation. Instead of treating log changes as small percentage changes, this ratio converts the estimated coefficients into proportional changes before taking their ratio. Using the level quantity response on the priced-loan sample in column (3) and the log spread response in column (6), the implied finite-change ratio is $(\exp(0.690) - 1)/(1 - \exp(-0.210)) \approx 5.25$. This value is close to the elasticity of 5 that Clayton, Maggiori et al. (2025b) use for traded goods, and far above the value of 1.8 they use for financial services. While these benchmarks are not directly comparable to our syndicated-lending setting, the comparison is informative: it suggests that the elasticity of substitution across financial services may be substantially higher when substitution occurs across vehicle currencies within the same lending market than off-the-shelf financial-services calibrations imply.

Currency-specific demand-side factors could affect the magnitude of this reduced-form elasticity, but they do not overturn the interpretation of the sign pattern. The key fact is that euro-denominated quantities rise while euro spreads fall relative to dollar loans. This joint movement is difficult to reconcile with a pure increase in borrowers' demand for euro credit, since such a demand shift would tend to raise, not lower, the relative price of euro loans. The falling spread therefore indicates that the dominant force is a relative supply- or cost-side shift in favor of euro credit, consistent with dollar-based sanctions risk making dollar lending more costly or constrained. We therefore interpret the estimate as a reduced-form elasticity of vehicle-currency substitution induced by responses to coercive policies on global banks that are specific to U.S. dollar lending, rather than as a clean structural demand elasticity.

All in all, the evidence presented in this section is highly suggestive of substitutability of vehicle currencies being higher than what the standard treatment of

i^{USD})), the more direct analogue to the gross price differential entering the framework of Clayton, Maggiori et al. (2025b), the implied elasticity would be substantially larger, since our spread differentials, expressed as a share of one plus the interest rate, are an order of magnitude smaller than in logs of the spread itself. Such a calculation would speak to the total elasticity of substitution across vehicle currencies as financing inputs, which our reduced-form estimate, focused narrowly on the settlement-risk channel, likely understates.

network-effect inertia in international currency equilibria would suggest (Gopinath and Itskhoki, 2022).

Appendix Tables A.19, A.20 and A.21 report, respectively, fixed-effect progressions, EUR-USD specifications with full interaction terms and contract controls, and within-borrower-lender estimates; together, they show that the vehicle-currency result is not driven by fixed-effect choice, relationship composition, or basic contract characteristics.

Table 1.5: Lender-Jurisdiction and Vehicle-Currency Substitution

	Quantity				Prices	
	Level	Log	Level	Log	Level	Log
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Lender-Jurisdiction Substitution						
Post $\times$ Russia $\times$ Coalition	-1.358*** (0.354)	0.081 (0.099)	-0.457 (0.402)	0.139 (0.156)	-6.15 (6.54)	0.007 (0.044)
Observations	87,304	27,237	15,705	15,705	15,705	15,705
Estimator	PPML	OLS	PPML	OLS	OLS	OLS
Sample	All	All	Priced Loans	Priced Loans	Priced Loans	Priced Loans
	(1)	(2)	(3)	(4)	(5)	(6)
Panel B.1: Vehicle-Currency Substitution						
Post $\times$ Russia $\times$ EUR	2.776*** (0.455)	0.674* (0.359)	0.690*** (0.191)	0.663*** (0.225)	-54.02*** (19.01)	-0.210** (0.087)
Observations	45,201	29,315	17,277	17,277	17,277	17,277
Estimator	PPML	OLS	PPML	OLS	OLS	OLS
Sample	All	All	Priced Loans	Priced Loans	Priced Loans	Priced Loans

Panel B.2: Reduced-form EUR-USD Elasticity of Substitution

Columns (4)/(6), Log-approximation: $\hat{\beta}_Q^{\log} / |\hat{\beta}_P^{\log}| \approx 3.156$

Columns (3)/(6), Finite-change Ratio: $\left[\exp(\hat{\beta}_Q^{PPML}) - 1 \right] / \left[1 - \exp(\hat{\beta}_P^{\log}) \right] \approx 5.252$

Notes. Coalition denotes a sanctioning-coalition lender parent. Fixed effects are borrower-year and lender-year for Panel A, and borrower-year and lender-currency-year for Panel B. Unit of observation is borrower-lender-year for Panel A and borrower-lender-currency-year for Panel B. USD is the omitted vehicle currency. *All* denotes the full estimating sample for the corresponding quantity specification. *Priced loans* denotes borrower-lender or borrower-lender-currency-year observations with observed benchmark spreads. Standard errors are clustered two-way by lender and borrower-year for Panel A, and by lender and borrower-currency-year for Panel B. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

1.7 A Capital Flows View of Geo-economic Power

We now further relate our findings to the emerging literature on geoeconomic power and economic coercion, connecting our detailed evidence to the macro-level debate over the sources and dynamics of global economic fragmentation. Clayton, Maggiori et al. (2025b) estimate that U.S. geoeconomic power, i.e. the ability to coerce other countries by withholding access to economic resources, primarily comes from American control over the supply of financial services. China’s power, conversely, relies on manufacturing. They show that, under the standard assumptions of their theoretical framework, the geo-economic power of an hegemon over a particular country (i.e. the potential loss imposed via withholding inputs) can be measured with a simple ex-ante sufficient statistic, based on the share of inputs controlled by the hegemon and the elasticity of substitution among various foreign and domestic inputs. They base their measure on trade data, and therefore relies on the WTO-OECD Balanced Trade in Services data to compute shares of controlled inputs in financial services. They show that, based on their empirical operationalisation, the American coalition geo-economic *financial* power over Russia declined very substantially, by almost 50%, following the imposition of the 2014 sectoral sanctions we study in this paper. This was a function of the non-linearity in power at the core of their modelling framework as well as a decline in the share of U.S. controlled financial inputs, again measured in the services trade data, by 10 percentage points, from a starting share of close to 95%.

In the previous Section 1.6 we provided suggestive evidence of higher substitutability in financial inputs - and particularly vehicle currencies - than what the off-the-shelf calibration used by Clayton, Maggiori et al. (2025b) would imply. We now put forward in this section a capital flows view on the “share of controlled inputs”: this therefore speaks to the second object - on top of an elasticity of substitution - that Clayton, Maggiori et al. (2025b) use to quantify geoeconomic power in their framework. We compute a simple quantification of share of controlled capital flows informed by our empirical results in the preceding sections and relying on BIS locational statistics. Importantly, we rely on the more detailed, restricted version

of the BIS locational banking dataset, which provides a breakdown of claims by both nationality (or residency) of banks and currency.

We provide a relevant empirical complement to trade-based measures, which are by definition residency based. We can compute our measurement both on a residence and nationality basis. Our approach is also able to account for both the jurisdiction and currency-specific frictions we have shown to matter for the implementation of financial sanctions.

1.7.1 Share of Controlled Capital Flows

Consider an hegemonic power h , exerting extra-territorial jurisdiction on the use of its currency k_h . Let $K_{bit}^{(z)}$ denote the claims of bank b on agents from country i at time t in currency z . Then we define the cross-border financial inputs of country i 's controlled by hegemon h at time t as:

$$\Phi_{it}^{(h)} = \underbrace{\sum_{b: J(b)=h} \sum_z K_{bit}^{(z)}}_{\text{Hegemon banks, All currencies}} + \underbrace{\sum_{b: J(b) \in \mathcal{C}_h} \sum_z K_{bit}^{(z)}}_{\text{Coalition banks, All currencies}} + \underbrace{\sum_{b: J(b) \notin \{h\} \cup \mathcal{C}_h} K_{bit}^{(z_h)}}_{\text{Hegemon currency}}. \quad (1.7.1.1)$$

where i is a country borrowing foreign capital, t is time, h is the hegemon country (e.g. the U.S.), z_h is the hegemon's currency (e.g. USD), $\mathcal{C}_h$ is the set of coalition countries associated with hegemon h , b indexes banks under jurisdiction $J(b)$, where jurisdiction can be defined on either a residence or nationality basis, and k indexes currencies.

The cross-border financial inputs of Russia under U.S. hegemonic control $\Phi_{RUS,t}^{(U.S.)}$ on a *nationality* basis and as per the BIS locational banking statistics are depicted by the bars in panel (a) of Figure 1.11, while its share of controlled input counterpart $\phi_{RUS,t}^{(U.S.)}$, normalised for total cross-border claims on Russia, is shown in panel (b) of the same Figure.

$\phi_{RUS,t}^{(U.S.)}$ was close to 100% of Russian cross-border borrowing prior to the invasion of Crimea but rapidly declined by about 26pp between 2014 and 2021, and then

by a further 8pp following the full-scale invasion of Ukraine and the imposition of Western blocking financial sanctions.

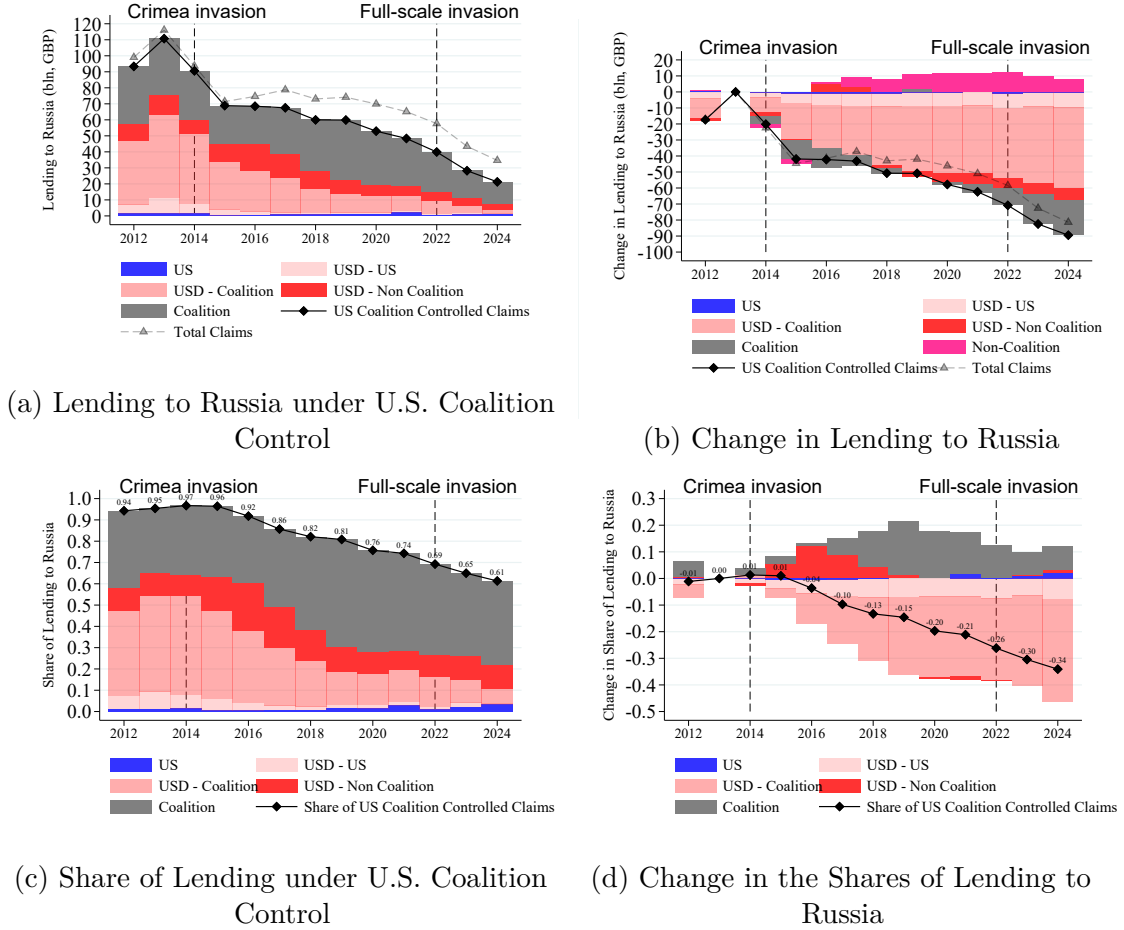


Figure 1.11: U.S. Coalition Controlled Claims - Nationality Basis.

Note – Amount outstanding of total cross-border claims including all counterparty sectors, all currency, all types of reporting country and all types of instruments. Lending converted from USD into GBP using quarterly averages of spot FX reported by the Bank of England. Some Other currencies start to be reported only from 2012Q2. Reporting of claims by Chinese banks starts in 2015 Q4. We match residence aggregates, and assign the difference between total lending to Russia from public BIS data and the sum of the flows plotted here by currencies to the corresponding groups of the non-coalition groups.

Source: BIS locational banking dataset.

The decline in the share of controlled inputs is therefore more significant in the capital flows data on a nationality-basis than in the financial services trade data used by Clayton, Maggiori et al. (2025b). It is therefore of interest to compare our $\Phi_{RUS,t}^{(U.S.)}$ on a *nationality* basis to its *residence* basis counterpart. Figure A.13 in the Annex provides a residence-basis equivalent to Figure 1.11. Figure 1.12,

shows the difference between the nationality and residence-basis measure of $\Phi_{RUS,t}^{(U.S.)}$. The nationality-basis $\Phi_{RUS,t}^{(U.S.)}$ is always between 4 and 8 percentage-points higher than its residence-basis counterpart. This is chiefly due to the residence-basis approach classifying claims by coalition banks booked in non-coalition residency as not being coalition controlled (the grey bars contributions). The differences in the other aggregates are inconsequential for the calculation of the controlled share as they only reflect a different residence/nationality allocation of dollar claims, which would be in any case aggregated in the third term of Equation 1.7.1.1. A single-digit difference in share of controlled inputs might seem small. However, that is not necessarily the case if, as in the framework developed by Clayton, Maggiori et al. (2025b), geo-economic power is non-linear, and relatively small changes in the share of controlled inputs can translate into large shifts in geoeconomic power.

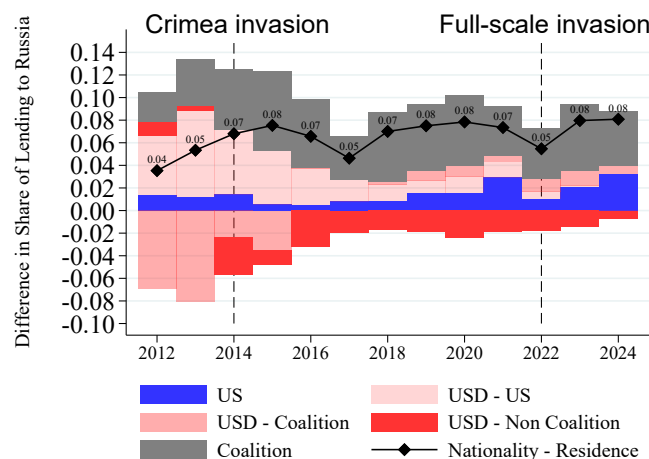


Figure 1.12: Difference between Nationality and Residence-basis Share of Controlled Claims.

Note – Amount outstanding of total cross-border claims including all counterparty sectors, all currency types of reporting country and all types of instruments. Lending converted from USD into GBP using quarterly averages of spot FX reported by the Bank of England. Some Other currencies start to be reported only from 2012Q2. The increase in claims from 2015Q4 in “Other” stems from the inclusion of Chinese banks in the BIS reported data. We match residence aggregates, and assign the difference between total lending to Russia from public BIS data and the sum of the flows plotted here by currencies to the corresponding groups of the non-coalition groups.

Source: BIS locational banking dataset.

The evolution of the components of $\phi_{RUS,t}^{(U.S.)}$ are also of interest: U.S. control over Russian claims overwhelmingly came from the U.S. dollar before 2014, as it

represented 70% of lending under U.S. Coalition control. However, its contribution declined drastically following the imposition of sectoral sanctions. Panels (b) and (d) in Figure 1.11 provide a decomposition in the change of lending to Russia and the share of controlled claims by the U.S. coalition along the key dimensions of Equation 1.7.1.1. As shown in Panel (b), an initial decline in the U.S. dollar share of lending by 20-25% in 2016 was initially almost completely offset by an increase in non-coalition dollar claims. As the decline driven by the dollar component reached about 40% before the 2022 full-scale invasion of Ukraine, non-coalition dollar claims also declined. The partial off-set to an overall decline in coalition controlled claims was then provided by coalition banks lending in non-USD currencies (as we know, mainly in euro).

All in all, the measurement presented in this section, which could be easily extended beyond our Russia-focused case study, highlights three relevant dimensions to the quantification of geo-economic power. First, firms respond to both nationality and residence-basis jurisdiction. As demonstrated by Coppola, Maggiori et al. (2021) a pure residence-basis approach can hide important patterns in global capital flows. This is therefore relevant to measuring control on financial inputs. Second, most of the U.S. control over global financial intermediation is likely to come from the use of the dollar as a vehicle currency, upon which the U.S. have been able to exercise an extra-territorial oversight via the dollar payment system. From a measurement perspective this underlines, for example, the importance of dollar invoicing in international trade when considering controlled trade inputs. Third, and finally, coalition countries seem to play a crucial role in the context we study. They first provide most of the control via U.S. dollar denominated claims, and then cushion the decline in the controlled share of financial intermediation in Russia by providing claims in non-dollar currencies.

Abstracting from measurement, our analysis points to within-coalition strategic interactions and the substitutability between vehicle currencies as important future avenues of investigation on the determinants and dynamics of geo-economic power.

1.8 Conclusion

In this paper, we have shown how sanction compliance risk and uncertainty over the extent of coercive actions by a hegemonic power exerting extra-territorial oversight on the use of its currency can affect the allocation of cross-border credit and the use of vehicle currencies in financial flows. We rely on the unique setting created by the 2014 Western sectoral sanctions on Russia, where the enforcement of lending restrictions on a sub-set of large Russian firms created sanction-compliance uncertainty in lending to non-sanctioned Russian firms. We document how, following the 2014 sectoral sanctions, a contraction in global lending to Russia was accompanied by a large rebalancing away from U.S.-dollar claims on Russia toward the euro, despite the formal symmetry of the sanctions and the absence of any currency-specific restrictions. Our results highlight the importance of two distinct frictions created by sanction compliance risk: jurisdiction-specific compliance risk faced by banks under the authority of sanctioning states, and currency-specific compliance and settlement risk arising from U.S. oversight over dollar payment systems.

Relying on firm-level balance sheet data we show that the rise in euro-denominated claims was driven by non-sanctioned Russian firms, ruling out sanction-avoidance motives. We then show, using bank-level data that institutions headquartered in sanctioning jurisdictions reduced their overall exposures, relative to banks headquartered elsewhere, while all banks—irrespective of ultimate-parent nationality—shifted their claims toward the euro. Loan-level evidence further demonstrates that dollar loans to Russian borrowers carried a sizeable settlement-risk premium relative to comparable euro loans, consistent with higher compliance costs. Together, these findings imply that vehicle-currency choice in international credit markets is highly sensitive to incentives embedded in the enforcement architecture of the hegemon’s currency and that vehicle currencies can be highly substitutable given a strong enough shock.

We derive from our empirical findings a capital flows-based measure of hegemonic control on global financial claims that distinguishes between oversight exercised over the hegemon’s own banks, oversight exercised indirectly over banks from

allied jurisdictions, and oversight arising from the use of the hegemon's currency. This measure can be computed from BIS locational data broken down by currency on either a nationality or residence-basis. Applied to the Russian case, this measure shows that the decline in dollar intermediation after 2014 substantially reduced the share of claims effectively subject to U.S. coalition oversight, although this decline was partly offset by an increase in lending by coalition-banks in other currencies.

Taken together, the evidence shows that anti-coercion responses need not originate solely from third-country governments seeking to reduce dependence on the hegemon. Private financial intermediaries adjust their behaviour in ways that limit the reach of hegemonic oversight when compliance risks become salient, contributing to global economic and financial fragmentation.

2

Dominant Currency Pricing Transition

with Giovanni Rosso and Roger Vicqu  ry

We study a unique episode of aggregate transition to dominant currency pricing: the "dollarisation" of UK exports in the aftermath of the 2016 Brexit referendum. Following the 2016 depreciation of the pound, the share of non-EU UK exports invoiced in the UK domestic currency decreased sharply by more than 20 percentage points. This was taken up by increasing invoicing shares in local currency, euro and US dollar. By 2019, the latter had become the primary invoicing currency for non-EU exports, in line with its long-standing dominant position in UK imports. Relying on transaction-level data on the universe of UK trade and employing shift-share and event-study identification strategies, we show that large, permanent shifts in currency risk can generate an aggregate transition in invoicing choices. Finally, we show that the shift in export pricing we document has important aggregate consequences for export pass-through and the allocative effects of price rigidities: a US dollar appreciation now depresses demand for UK exports by twice as much as before this 'dominant currency pricing transition'.

JEL Classification: F14, F31, F41

This chapter is also circulated as a Bank of England working paper. We are grateful to Kai Arvai (discussant), Kenza Benhima (discussant), Ambrogio Cesa-Bianchi, Andrea Ferrero, Jay Hyun (discussant), Robert Johnson, Isabelle Mejean (discussant), Thomas Prayer, Ricardo Reis, H  l  ne Rey and Liliana Varela for valuable comments and suggestions. We would also like to thank for helpful discussions the participants to the LSE-Oxford Workshop in International Macroeconomics and Finance, the Joint BIS-BoE-ECB-IMF Spillovers Conference, the BdF-BoE-BdI International Macroeconomics Workshop, the ESCB Research Cluster 2 Annual Workshop, the 10th Annual West Coast Workshop in International Finance, the Macro-group seminar at University of Oxford, and the Brown-bag seminars at the Bank of England. All errors and omissions remain our own. The views expressed in this paper are those of the authors and not necessarily those of the Bank of England and its committees.

2.1 Introduction

The currency of invoicing of international trade is a defining question in international macroeconomics. The fact that a large share of international transactions are denominated in US dollars is central to our understanding of the international propagation of shocks and the international financial system (Gopinath, Itskhoki and Rigobon, 2010). This dollar Dominant Currency Paradigm (DCP) is underpinned by network effects and is consistent with remarkably stable patterns in invoicing currency choices (Boz et al., 2022). However, we know that discontinuities in the role of international currencies have occurred in the past. Our paper empirically contributes to the key question of which forces can generate changes in dominant currency equilibria. We offer three contributions.

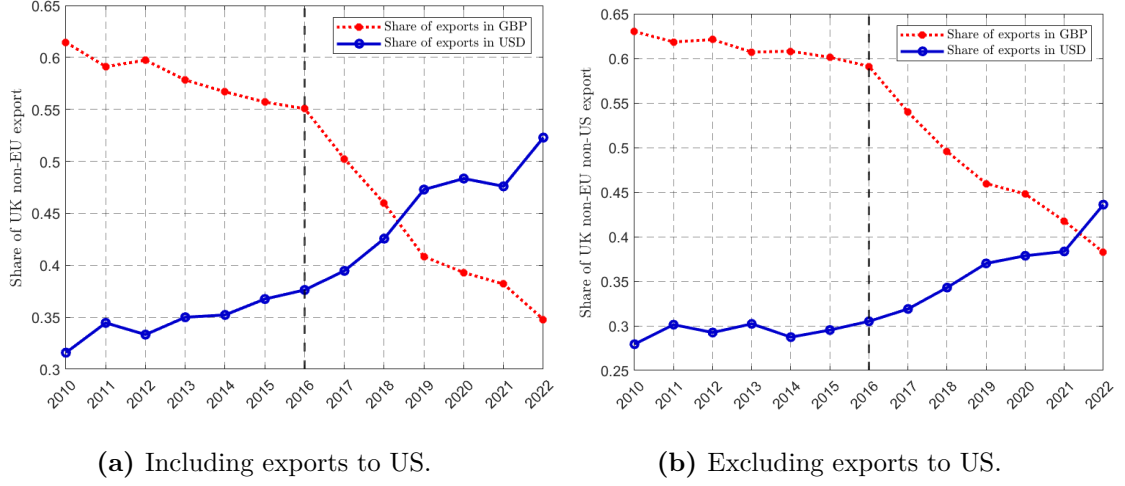
First, we document, using transaction-level data, a unique episode of rapid aggregate shift in export pricing patterns in a large developed economy: the dollarisation of UK exports in the aftermath of the 2016 Brexit referendum. As aggregate import pricing remained characterised by dominant currency invoicing, this transition meant that UK exporters aligned the invoicing currency of their foreign receivables to that of their payables.

Second, we provide causal evidence that large FX-movements can endogenously determine invoicing currency decisions, potentially generating an aggregate transition in pricing paradigm. This channel operates through firms more exposed to valuation effects from operational currency mismatches and explains most of the post-Brexit transition to dominant currency pricing.

Third, we show that the causal effect of *firm-level* invoicing currency choice on exchange-rate pass-through of export prices and quantities changes as the basket of invoicing currencies changes. This has significant macroeconomic implications for the UK: a US dollar appreciation now depresses demand for exports by twice as much as before the Brexit referendum and the *dominant currency pricing transition* it sparked.

Our study relies on transaction-level data on the universe of UK trade, focusing on non-EU, non-US trade between 2010 and 2022. Until 2016, the majority of

Figure 2.1: CURRENCY SHARES OF UK NON-EU EXPORTS.



Source: HMRC administrative datasets, UK non-EU exports, 2010–2022.

UK non-EU exports¹ were invoiced in the “producer” currency, the British pound. However, in the aftermath of the June 2016 Brexit referendum and the subsequent depreciation of the pound, the share of non-EU UK exports invoiced in pounds started to sharply decrease. It went from about 55% in 2015 to 35% in 2022. At the same time US Dollar (USD) invoicing has surged from around one third to nearly 55% (Figure 2.1).² Thus, the majority of extra-EU UK exports is now invoiced in USD, the dominant vehicle currency of international trade (Boz et al., 2022): a *dominant currency pricing transition*.

The conditions under which new equilibria in the use of international currencies might emerge are a key but relatively unexplored question in the DCP literature (Gopinath and Itskhoki, 2022) and one that is increasingly relevant as questions are raised on the sustainability of current levels of Dollar dominance in a more multi-polar world (Frankel, 2023). Our study provides a unique empirical setting to study

¹As per EU statistical regulations, the currency of invoicing for UK-EU trade was not recorded by the UK customs. Similarly to other studies relying on firm-level evidence in EU countries, such as Amiti et al. (2022), we therefore focus on non-EU trade.

²We also report headline results excluding the US as a non-EU destination to control for the fact that the USD is a producer rather than vehicle currency for that country. The invoicing change is similarly large when we exclude exports to the US: the GBP value share of UK exports to non-EU non-US countries has fallen from about 63% before 2015 to 38% by 2022, with USD invoicing increasing from one third to 45% (Figure 2.1).

aggregate changes in international trade pricing paradigms, using granular firm-level data. Although we know from history that abrupt shifts in the international monetary system can occur (Eichengreen, Mehl et al., 2018; Vicqu  ry, 2022), transitions such as the one we study in this paper have been remarkably rare in recent decades. The stability of aggregate invoicing patterns is apparent in the cross-country dataset compiled by Boz et al. (2022) and, *a fortiori*, in the existing firm-level data studies focusing on a selected group of countries. As an example, the transition we study is faster and either larger or comparable in magnitude to the one experienced by Eastern European countries that shifted their invoicing from dollars to euros as part of EU accession in the early 2000s (Mehl and Mlikota, 2023).

Why did this *Dominant Currency Pricing Transition* materialise? A remarkable feature of our empirical setting is that the transition took place in the aftermath of a large depreciation, driven by unexpected, exogenous political developments. In this paper we exploit this to identify a novel currency-mismatch valuation channel of dynamic currency invoicing choice. In a nutshell, we show that the depreciation generated a transition in invoicing choices for firms exhibiting larger currency mismatches in the wake of the depreciation, i.e. with most of their exports invoiced in GBP while most of their imports invoiced in other currencies. Intuitively, with prices sticky in the currency of invoicing, the sudden GBP depreciation sharply reduced revenues and increased marginal costs for such firms, prompting them to revise their invoicing preferences. Our estimates suggest that this channel may have accounted for most of the dominant currency pricing transition. We find this novel channel to operate over and above determinants of invoicing choice such as strategic complementarities and market power.

Finally, we find that this large transition has important aggregate consequences for export pass-through (ERPT) and the allocative effects of price rigidities. UK exports exhibit significantly higher elasticity to USD exchange rate movements after the Brexit referendum, with a US dollar appreciation estimated to depress demand for exports by twice as much as before this transition.

We begin our analysis by describing our empirical setting and dataset in Section 2.2. Specifically, we investigate the firm-level patterns of currency mismatch in the wake of the Brexit referendum. We document a clear pattern, whereby the more firms were operationally exposed to the post-referendum depreciation, the more they reduced their invoicing in pounds - and conversely increased vehicle currency pricing, particularly in USD - after June 2016.

In Section 2.3 we then study this “currency-mismatch valuation” channel relying on two main empirical specifications. First, we present a shift-share identification strategy where the effect of currency mismatches on invoicing decisions is given by an exposure index composed of a destination-specific shift (in the exchange-rate) and a firm-specific share (pre-shock net currency exposure). Second, we turn to a dynamic empirical exercise with a firm-product-destination level event-study approach. Both approaches confirm that the exposure to the depreciation driven by pre-shock operational hedging patterns played a key role in driving the firm-level shift away from GBP invoicing. We provide a quantitative exercise to show that the lion’s share of the UK transition can be accounted for by this novel mismatch valuation channel of invoice currency choice.

Finally, the dominant currency transition we observe raises the question of whether such a large shift in invoicing changed aggregate trade elasticities to exchange-rate movements, and the USD in particular. Our results in Section 2.5 point to important macroeconomic consequences of dominant currency transition. We test directly for changes before and after 2016 in the “allocativity” of prices, i.e. the latter’s ability to drive demand to or away from quantities as they decrease or increase, using a two-stage procedure analogous to Amiti et al. (2022) for both our pre- and post-2016 sample. Our results confirm expected expenditure-switching pattern of a decline in quantities demanded following an increase in their prices in local currency. Notably though, we find that this drop in demand is significantly larger after than before 2016, specifically by a factor of two.

Related literature. This paper draws on and contributes to four main strands of the literature.

First, our study follows a flourishing literature on currency invoicing decisions and exchange-rate pass-through using disaggregated microdata (Goldberg and Tille, 2016; Devereux et al., 2017; Chen et al., 2022; Chung, 2016; Barbiero, 2022; Auer et al., 2021; Crowley, Han and Son, 2022). A distinguishing feature of our data setting is the presence of a large aggregate transition in invoicing patterns, driven by a large exogenous shock. This allows us to investigate the dynamics of currency invoicing choice. Previous studies, constrained by the remarkably stable nature of aggregate invoicing patterns they observe, looked at determinants of currency invoicing in a *static* framework. As a prominent example, Amiti et al. (2022), looking at Belgian trade micro-data, find evidence in favour of DCP being driven by strategic complementarities and the willingness of firms to match the currency of their inputs. In their sample, switches in invoicing represent only 2.6% of firm-product-destination-month observations over four years. Previous studies relying on UK micro-data up to the Brexit referendum paint a similar picture. In their analysis of ERPT around that event, Corsetti, Crowley et al. (2022) report a slow-moving aggregate trend towards more USD pricing.³

Closely related to our study, Crowley, Han and Son (2022) analyse the firm-level determinants of invoicing choice for UK exporters, looking at the pre-Brexit part of the sample we consider. They highlight prior experience in the use of the dollar, as well as strategic complementarities, as key determinants of DCP in the cross-section. Similarly to the empirical setting we examine, the work of Auer et al. (2021) relies on a large exogenous movement in exchange rates. They investigate the implications of invoicing in different currencies amid the de-pegging of the Swiss franc in 2015, which led to a sharp appreciation. In contrast with our study, only 2.5% of observations switch their invoicing pattern in the period considered. A study relying on the same CHF appreciation episode and transaction data is

³We show the pre-2016 trend towards USD pricing for export invoicing is entirely due to trade flows towards the US, while the share of USD invoicing towards non-EU, non-US destinations remained stable until 2016.

Bonadio et al. (2020). Our key finding that invoicing patterns can endogenously respond to foreign-exchange movements relates and borrows from some of the tools used in Barbiero (2022) to study the cash-flow effects of currency mismatches for French firms.

In line with previous literature, we also investigate the macroeconomic implications of invoicing in different currencies for export prices and quantities. Amiti et al. (2022) found a causal relationship between currency invoicing, prices and quantities of exports. We confirm in our study that changes in prices are allocative, but additionally show that, as the composition of the basket of invoicing currencies changes, aggregate quantities elasticity also changes. This is all but a foregone result given the ambiguous effect of dollarisation on price rigidities, as highlighted by McLeay and Tenreyro (2024).

Second, our study relates to the literature on endogenous currency choice. Mukhin (2022) provides a general equilibrium model of the international price system where dominant currencies arise endogenously as a result of input-output linkages, and variances and covariances of exchange rates. Furthermore, Amiti et al. (2022) draw on previous contributions from Engel (2006) and Gopinath, Itskhoki and Rigobon (2010) to provide a static framework for studying determinants of currency of invoicing.

Third, our study follows a large literature on “original sin” (Eichengreen and Hausmann, 1999) and the role of foreign-exchange mismatches and in international borrowing. The effect of currency mismatches in international trade has received comparatively less attention but recent contributions have examined the role of valuation effects (Barbiero, 2022) and the extent to which firms involved in international trade are able to rely on derivative instruments to hedge their currency risk (Alfaro, Calani et al., 2023; Berthou et al., 2022; Lyonnet et al., 2022).

Finally, our paper speaks to the literature concerned with discontinuities in the international monetary system. An important body of historical work (Eichengreen and Flandreau, 2009; Chițu et al., 2014; Vicquéry, 2022) has highlighted how shifts

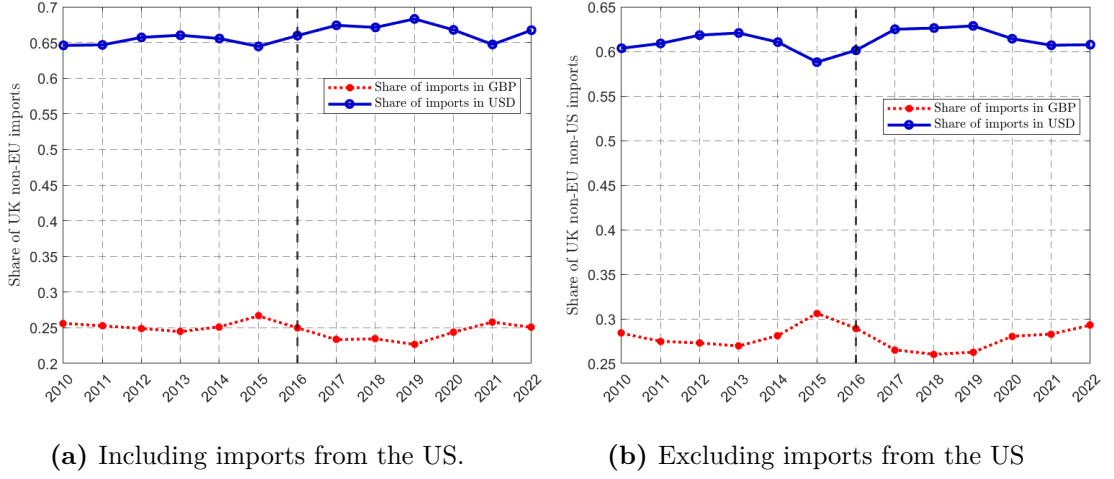
in past patterns of dominant currencies have not been gradual nor rare. As summarised by Eichengreen, Mehl et al. (2018), network externalities have not prevented rapid shifts in dominant currency status in the past, nor can explain the transition from pound to dollar dominance that occurred as soon as the interwar period. This historical literature has inspired several theoretical frameworks, focusing on multiple equilibria in the international monetary system (Krugman, 1980; Rey, 2001; Farhi and Maggiori, 2018) or certain historical features of the global safe asset issuer (Coppola, Krishnamurthy et al., 2023; Arvai and Coimbra, 2023). Our paper also relates to a debate on whether the euro or the renminbi might play a more prominent role in the future, and which policies are more likely to foster their use as vehicle currencies (Ito and Kawai, 2016; Bahaj and Reis, 2022). Recent geopolitical events have in particular raised the prospects of moves towards de-dollarisation of sanctioned countries, which Berthou (2023) and Chupilkin et al. (2023) find some evidence of looking at invoicing microdata. Closely related to our paper, Mehl and Mlikota (2023) consider rare episodes, related to the EU enlargement process in the early 2000s, of aggregate invoicing transitions from the dollar to the euro, and evaluate theoretical predictions on the relevant channels of dominant currency transition. In contrast to our study, they rely on cross-country evidence at the annual frequency.

The rest of the paper is organised as follows. Section 2.2 presents our dataset and highlights the new stylised facts about currency choice and its key mechanisms. Then in Section 2.3 we describe our baseline empirical specifications and in Section 2.4 our results. In Section 2.5, we explore the aggregate implications of this transition. Finally, Section 2.6 concludes.

2.2 Data and key mechanism

In this section, we describe our dataset and investigate the firm-level drivers of the transition documented in Figure 2.1. Recent contributions on endogenous currency choice (Mukhin, 2022; Amiti et al., 2022) identify the desire to reduce the volatility of desired prices (due to underlying exchange rates) as the main

Figure 2.2: CURRENCY SHARE OF UK NON-EU IMPORTS.



Source: HMRC administrative datasets, UK non-EU imports, 2010–2022.

influence on a firm’s steady-state invoicing decision. The steady-state we observe prior to the 2016 Brexit referendum shock is one where large firms are mostly ‘long’ GBP and stably so for many years. The Brexit depreciation of the pound drives a dynamic invoicing response leading to a different equilibrium. In other words, a sharp depreciation meant that many firms experienced unprecedented losses, and, as long as risks to the future value of the GBP remained tilted to the downside, further expected losses. We find that these firms are those that account for the bulk of the transition to USD invoicing of the UK economy. We dub this mechanism ‘currency-mismatch valuation channel’.

2.2.1 Data

In this section we describe our data. Our main source is transaction-level customs declaration of export and import flows for the UK, combined with firm-level information on tax returns from HMRC, as well as balance sheet and capital structure data from FAME-BvD and Capital IQ, respectively. We also collect aggregate product-country trade series from UN Comtrade, realised bilateral exchange rates from the BIS and exchange rate forecasts from Consensus Economics.

Customs data HMRC (His Majesty’s Revenue and Customs) collects data on the universe of exports and imports recording the day (when the product enters or clears UK customs), the UK trader identifier, Combined Nomenclature (CN) 8-digits product, country of destination or origin, value in pound, quantity and, for non-EU transactions (from firms whose yearly exports are above the threshold of £100,000), the currency of invoicing. These data on currency of invoicing are available from January 2010 up to and including December 2022 (our latest data-point available), thus spanning an interval of six years on either side of the 2016 EU referendum. We follow Freeman et al. (2024) to set up and clean the dataset, in particular in aggregating HMRC trader identifiers at the level of VAT units, so as to have a clearer interpretation of what constitutes a “firm” in our data. Finally, since USD pricing considerations for exports towards the US represent a “special” case, as USD pricing should be classified as local currency pricing (LCP) for exports towards the US, we will always indicate and justify whether the empirical analysis includes or not exports/imports to/from the US. We give further details on our dataset in Appendix B.

VAT data The HMRC Value Added Tax (VAT) dataset sources information for all UK businesses with annual taxable turnover above a threshold directly from tax returns.⁴ For every financial year, it includes details on VAT IDs’ total sales and purchases. From this dataset we employ data on total firm-level output and inputs in 2015, the latest available pre-Brexit financial year. We then use this information to calculate different measures of firm-level exposure for our empirical analysis.

Balance sheets We match customs data with datasets including information on businesses’ balance sheets from two main sources: FAME-BvD and Capital IQ. The former dataset provides detailed balance sheet data for UK firms. While the frequency of the observations is exclusively annual, the coverage of the dataset is large, including a large sample of private businesses. Furthermore, we source

⁴This threshold was £77,000 in 2012-2013 and then was increased to £85,000 in 2019-2020.

information on firm-level *outstanding* liabilities by currency and debt instrument from S&P Capital IQ.

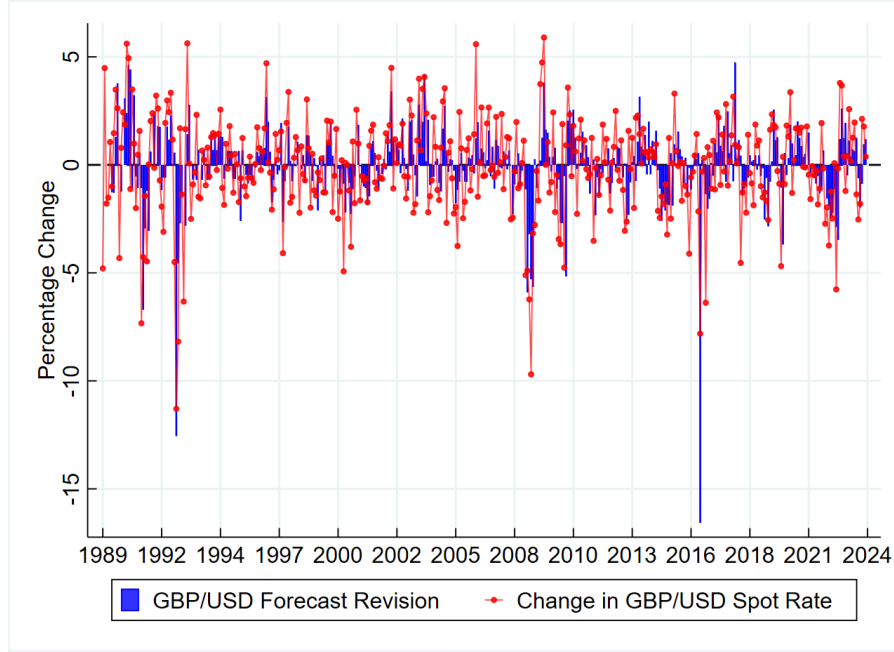
UN Comtrade dataset We retrieve data on HS6 product-origin-destination-month level exports and imports from UN Comtrade to create firm-specific measures of exporter’s market shares within destinations. To clean the raw data, we exclude re-exports, re-imports, and trade with the UK. We then aggregate the data to the HS6 product-country-quarter level.

Exchange-rate data and forecast series We source bilateral spot daily exchange rates against the US dollar from the BIS, and monthly forecast for a select number of currencies from Consensus Economics.⁵ The latter is a widely recognised survey of professional forecasters of exchange rates, including banks and market participants. It provides both short-term and long-term exchange rate forecasts across multiple currency pairs, e.g. at 3 month and 1 year ahead, which are the series we consider in our analysis. The Consensus Forecast dataset is particularly valuable for its reflection of market participants’ expectations, which we assume are likely to be a good proxy for and broadly capturing also the expectations of non-financial businesses such as UK exporters and importers.

Liabilities We source firm-level outstanding liabilities by currency and debt instrument from S&P Capital IQ (Adams and Verdelhan, 2022; Rodnyansky et al., 2026). The dataset includes active and inactive public and private ultimate-parent companies filing financial statements. This information is available mostly at annual rather than quarterly frequency. Liabilities are grouped into Bonds

⁵The economies whose currencies we have forecast data for are: Euro-Area, Argentina, Armenia, Australia, Azerbaijan, Bangladesh, Belarus, Bolivia, Brazil, Canada, Chile, China, Colombia, Costa Rica, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Georgia, Guatemala, Honduras, Hong Kong, India, Indonesia, Israel, Japan, Kazakhstan, Korea, Malaysia, Mexico, New Zealand, Nicaragua, Nigeria, Norway, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Russian Federation, Saudi Arabia, Singapore, South Africa, Sri Lanka, Sweden, Taiwan, Thailand, Turkey, Turkmenistan, Ukraine, United Kingdom, Uruguay, Uzbekistan, Venezuela, Vietnam.

Figure 2.3: REVISIONS TO 1-YEAR AHEAD FORECAST OF THE GBP/USD EXCHANGE RATE AND REALISED SPOT MONTHLY CHANGES OF GBP/USD.



Source: Consensus Economics and Bank of England.

and Notes, Term Loans, Capital Leases and Other Borrowing. When computing currency shares of debt, Capital IQ first converts liabilities into US Dollars.

2.2.2 Background: The 2016 Pound “Crash”

We argue that, compared to similar episodes such as the GFC, the 2016 pound crash implied a revision of agents’ expectations that was significantly more sudden and which permanently negatively shifted perceptions of UK currency risk.

A Uniquely Sudden Revision of Professional FX Forecasts

Firstly, while the *realised* drop in the exchange rate was smaller in magnitude than in 2007-2009, it unfolded in a matter of hours (Costa et al., 2024) rather than over several months. It implied a sudden radical update of expectations on the future path of the UK economy, which had meaningful economic implications (Dhingra and Sampson, 2022). Looking at professional forecast revisions we can show that the pound crash of June 2016 implied a much stronger signal to market participants

than previous episodes of pound weakness, including during the GFC. Figure 2.3 shows the revision of the 1-year ahead Consensus Forecast expectations⁶ for the GBP/USD exchange rate (the blue bars) alongside realised GBP/USD monthly changes (in red). Consider how, typically, forecasters tend to adjust their monthly forecast by roughly the amount of the observed appreciation/depreciation. This is in line with the view of the exchange rate as a random walk. In June 2016, however, we see that a realised drop of around 6% was met with a forecast revision that was three times as large. That is, given the size of the realised depreciation, agents adjusted their expectations of the path of the exchange rate significantly more in 2016 than they did in any other episode, suggesting that this episode was indeed different. As the invoicing decision is a forward-looking one, what matters is not the exchange rate realisation per se, but how it is incorporated in the way agents form expectations. The 2016 depreciation represents a clear outlier in this sense.

Permanently More Negative Perceptions of UK Currency Risk in Firms' Earnings Calls

Secondly, this revision of expectations was not only very significant in magnitude but resulted in a permanent shift in agents' perception of UK currency risk. This is apparent from a simple text-based analysis of earnings calls by UK listed firms⁷, in line with similar measures pioneered by Hassan et al. (2019) to analyse firms' perceptions of political risk.

In a nutshell, we identify how many times keywords related to UK currency risk, such as “weak gbp” or “pound depreciation”, appear in the transcripts of these calls. We compute the number of sentences in which mentions of these phrases of interest occur, normalised by the total number of sentences, to construct two indices, of GBP "risk" and GBP "negative sentiment" respectively. Following Hassan et al. (2019) the GBP "risk" index is constructed as:

⁶The implications of the chart are robust to using other horizons for the forecasts (e.g. 3-month or 2-year).

⁷We perform the analysis relying on NL Analytics, an automated tool that allows the extraction of data from transcripts of the universe of English-language earnings calls.

$$GBP_{Risk_{i,t}} = \frac{1}{L_{i,t}} \sum_{l=1}^{L_{i,t}} \{l = \text{"gbp"}, \text{"depreciation"}, \text{"pound"}, (...)\} \times 1[|l - r| < 10] \quad (2.2.2.1)$$

where $L_{i,t}$ is the total number of words occurring in the earnings call of firm i in quarter t , and r represents the location of the nearest word indicating risk or uncertainty.

Similarly the GBP “sentiment” index as

$$GBP_{Sentiment_{i,t}} = \frac{1}{L_{i,t}} \sum_{l=1}^{L_{i,t}} \{l = \text{"gbp"}, \text{"depreciation"}, \text{"pound"}, (...)\} \times \left(\sum_{c=l-10}^{l+10} S(c) \right) \quad (2.2.2.2)$$

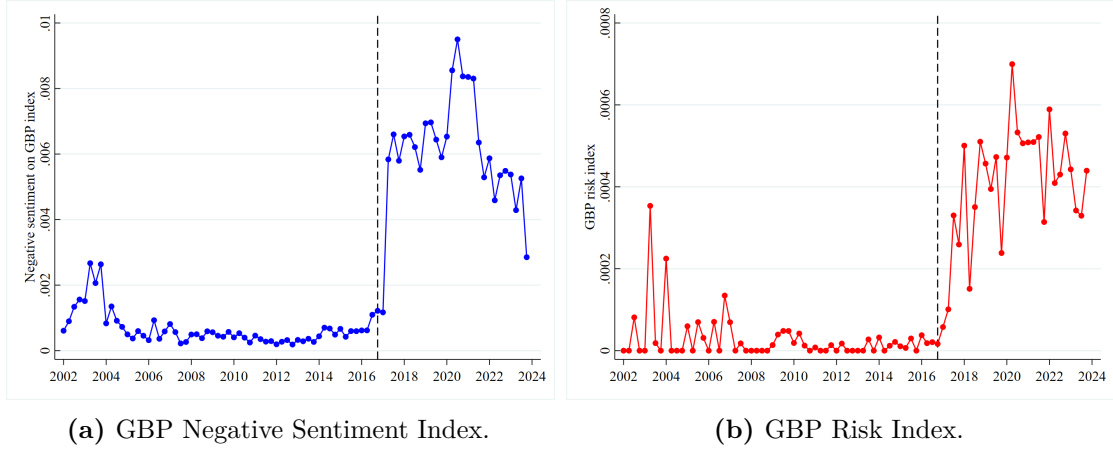
which conditions on proximity to positive or negative words and where S indicates sentiment, that is it takes on a different sign depending on whether the term has a positive, negative or neither connotation.

Figure 2.4 plots the quarterly average across firms of the two indices. We identify a clear structural break in the perception of currency risk by UK firms. Before 2016, except for a modest uptick in 2003 and around the GFC, both risk and negative sentiment about the pound and UK currency risk remained at very low levels. Risk and negative sentiment spiked up in 2016 and keep fluctuating around a permanently new higher mean. This suggests persistently higher levels of perceived currency risk in the UK following the Brexit referendum and the 2016 pound crash.

2.2.3 Currency mismatch, sudden exchange-rate depreciation and valuation effects

In the benchmark case of fully flexible import and export prices, the denomination of transactions should not matter (Gopinath and Stein, 2021). However, a large literature (Amiti et al., 2022; Auer et al., 2021; Corsetti, Crowley et al., 2022) finds that international prices are sticky in general and, crucially, in the currency of denomination. That is, if a British company sells a good to Japan at a unit price of £2, they will not immediately adjust the sterling price when faced with a

Figure 2.4: QUARTERLY AVERAGES ACROSS FIRMS OF TEXT-ANALYSIS INDICES BASED ON EARNINGS CALLS OF LISTED UK COMPANIES.



Source: NL Analytics and authors' calculation.

JPY/GBP exchange-rate movement. Thus, if the GBP appreciates this will amount to an increase in the price observed by the foreign customer, and vice versa for a JPY appreciation. Specifically, for the case of the Brexit-related GBP depreciation, Corsetti, Crowley et al. (2022) find that export prices for GBP-invoiced transactions went up gradually and converged to the rate of the sterling depreciation after about 72 weeks. The same holds on the import side. If a British firm is importing the inputs for its good in USD, bilateral movements in the USD/GBP exchange rate will have a direct effect on its marginal cost.

Accordingly, a firm might try to match the denomination of its imports and exports; in this case, it is said to be *operationally hedged*. In other words, the business is less exposed to exchange-rate movements. If instead a firm is exporting in its own currency more (less) than it is importing, we can say it is 'long' ('short') the domestic currency, i.e. set to lose (gain) money from a domestic depreciation. As shown by Figure 2.1 and Figure 2.2 in our data, the UK economy before 2016 in the aggregate found itself in a 'long' position, with around 60% of exports invoiced in GBP and 60% of imports in USD. Similarly, looking at the firm-level positions, we see that not only the UK in the aggregate but also UK firms found themselves in this situation pre-2016, as the majority (86%) of firms exported in GBP more

than they imported in GBP (Figure 2.5). More formally, we define a measure of currency mismatch (net exposure) as

$$Exposure_{f,2015} = \frac{\sum_j (\mathcal{E}_{fj,2015}^{\mathcal{L}} - \mathcal{I}_{fj,2015}^{\mathcal{L}})}{Total\ Trade_{f,2015}} \quad (2.2.3.1)$$

where $\mathcal{E}_{fj,2015}^{\mathcal{L}}$ are exports of firm f to country j invoiced in GBP, and $\mathcal{I}_{fj,2015}^{\mathcal{L}}$ imports of firm f from country j in GBP in 2015. The sum across all destination/origin countries is normalised by total gross trade (exports plus imports) of a firm in the same year in order to make net exposure comparable in the cross-section. Figure 2.5 sets $Exposure_{f,2015}$ on the x-axis, and shows that indeed the vast majority of UK firms, around 86%, exhibited a long GBP position.

With sticky prices, firms with such a long position are set to lose from a sharp and unexpected depreciation. Figure 2.6 shows that indeed this is what happened in 2016 with sharp GBP downward movements in the aftermath of Brexit. Figure 2.6 takes the exposure measure in (2) and enriches it by looking at bilateral depreciations of the GBP vis-a-vis all destination j currency. Formally,

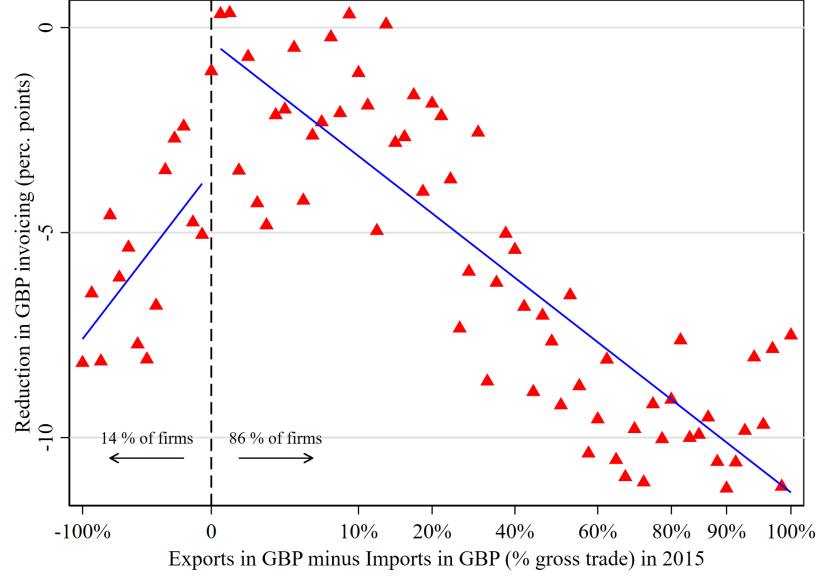
$$s_{f,t} = \frac{\sum_j [(\mathcal{E}_{fj,2015}^{\mathcal{L}} - \mathcal{I}_{fj,2015}^{\mathcal{L}}) \times \Delta e_{j,t}^{\mathcal{L}/j}]}{Total\ Trade_{f,2015}} \quad (2.2.3.2)$$

where $\Delta e_{j,t}^{\mathcal{L}/j}$ is the change in the bilateral GBP-country j exchange rate.⁸ For example, a positive $\Delta e_t^{\mathcal{L}/\$}$ indicates a depreciation of the GBP vis-a-vis the USD. Intuitively, $s_{f,t}$ captures the gains/losses from unhedged positions of firms vis-a-vis exchange rates movements.⁹ For example, assume that a firm has a net exposure to the GBP of 50% of gross trade in its trade to Argentina. If a 10% depreciation of the GBP against the peso occurs, the firm makes a loss of 5% of gross trade in the absence of price adjustment. Figure 2.5 shows that the depreciation of 2016 translated into an unprecedented negative shock for exposed firms (average loss of 4% of gross trade). A similar time-series picture would emerge if we were to look at

⁸With a slight abuse of notation, a superscript j indicates the currency of the destination while a subscript j indicates the country itself.

⁹In the sticky prices limit, as in Barbiero, 2022.

Figure 2.5: FIRM LEVEL CURRENCY MISMATCHES AND REDUCTION IN GBP INVOICING.



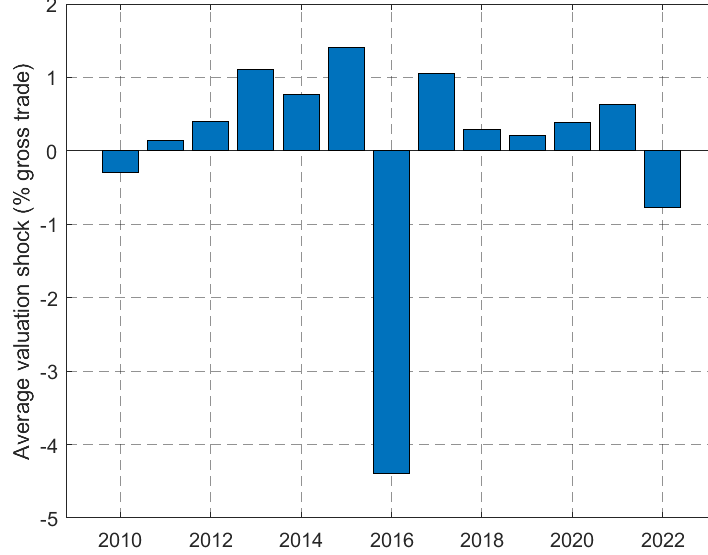
Note. – On the y-axis is plotted the firm-level change in GBP share of exports btw 2015 and 2019 in p.p. The x-axis plots bins of ‘exposure to gbp’ i.e. firms’ exports in GBP minus imports in GBP. Each bin is labelled with the corresponding level of exposure as a percent of gross trade. The arrows as well as the density of bins on the right tail of the distribution indicate that many more firms are ‘long’ GBP than ‘short’ or hedged.

Source: HMRC administrative datasets, UK non-EU non-US exports, 2010–2022.

the total losses across firms. It seems natural to wonder whether such a big shock could be a candidate trigger for the transition that occurred after 2016.

Going back to Figure 2.5 we can see that indeed firms with larger $Exposure_{f,2015}$ (that hence experienced a larger shock) are those that reduced their GBP invoicing by more. To recap, firms who were exporting more than importing in the domestic currency were a vast majority (86%, Figure 2.5) before the depreciation. This long position, together with the Brexit depreciation, meant an unprecedented shock (Figure 2.6). Finally larger shock exposure is associated with larger move away from invoicing in the domestic currency (Figure 2.5). We aim to test this ‘currency-mismatch valuation channel’ formally in the next section.

Figure 2.6: EXCHANGE RATE GAINS/LOSSES FROM FIRMS' CURRENCY MISMATCHES.



Note. – The graph plots the depreciation shock $s_{f,t}$ defined in equation (2), averaged across firms. It expresses how much on average firms gain/lose from GBP exchange rate movements in the sticky prices limit. Negative values represent losses.

Source: HMRC administrative datasets, UK non-EU non-US exports, 2010–2022.

2.3 Transaction-level empirical analysis

In this section we explicitly test whether a currency-mismatch valuation channel drove firm-level transitions from producer to dominant currency pricing, above and beyond the determinants of invoicing currency choice commonly considered by the literature. We identify the currency-mismatch channel by comparing - at the firm-destination-product level -the invoicing decision of firms with high operational exposure to the Brexit-GBP shock, relative to firms with more operational hedging. We first present results in a static regression setting based on a shift-share identification strategy. We then turn to a dynamic setting, relying on an event study approach performed around the date of the Brexit referendum and the ensuing devaluation of the GBP. Our results confirm the relevance of this operational hedging channel. We show it can account for most of the UK transition to dominant currency pricing by conducting a quantitative back-of-the-envelope exercise based on our estimates.

2.3.1 Static regression analysis

We estimate the effect of currency-mismatches on invoicing choice relying on the following benchmark specification

$$y_{ft}^h = \beta_k s_{f,t} + Controls_{f,t} + \alpha_f + \delta_t \times \Delta_t + u_{ft} \quad \text{for } h=\{\$, \text{€}, \text{£}\} \quad (2.3.1.1)$$

where $y_{f,t}^h$ is the share of exports by firm f (aggregating across all products p to destinations j) invoiced in currency h in quarter t , $\delta_t \times \Delta_t$ is a quarter fixed effect interacted with a measure of the gap since the firm last exported so that we control for potential informativeness of the trade patterns¹⁰, α_f is a firm fixed effect, $s_{f,t}$ is the exposure-weighted exchange-rate measure we presented in Section 2.2.3.2. Standard errors are clustered at the firm level.

Equation 2.3.1.1 includes several controls. Strategic complementarities are shown to play a key role in currency invoicing decisions (Amiti et al., 2022; Mukhin, 2022; Rey, 2001). That is, an exporter’s optimal markup might depend strategically on the prices, and therefore currency of invoicing, of its competitors in the destination. To account for these channels, we include: (a.) the average share of exports invoiced in currency h in that specific HS4 sector in quarter t and (b.) the share of exports invoiced in h at t for the largest firm in the sector. Finally, we include the product-destination firm-level market share as a further control. We will detail this choice and the reason behind it in Section 2.4.4.

We also consider additional measures of net currency mismatch exposure at the firm level. These include the long and short position of firms in the currency of the destination country and in US dollars, capturing revaluation effects not accounted for by the GBP net position; for example, firms that were operationally long USD, might want to invoice even more in USD following their post-Brexit depreciation gains in GBP terms. In the interest of space, we provide more details on these measures in Appendix B.1.

¹⁰Notice that, given the sporadic pattern of exporting, i.e. the fact that firms might not export every quarter, we consider here exchange-rate changes from the last time the firm exported, rather than the change against the previous quarter.

Identification

Borusyak et al. (2022) show that for coefficients β in Equation (2.3.1.1) to be consistently estimated, i.e. $\hat{\beta} \xrightarrow{p} \beta$, and uncover a causal effect, we need an exclusion restriction to hold. In particular, if we interpret our indices as composed of a destination-specific shift - the exchange-rate change - and a firm-specific share - the pre-shock net currency exposure from (2.2.3.1) -, we can express the key orthogonality condition needed for identification as

$$\text{Cov}[I_{ft}, u_{ft}] = \sum_j \text{Exposure}_{fjt} \Delta e_{jt} \phi_{jt} \rightarrow 0 \quad (2.3.1.2)$$

where $\text{Exposure}_{fjt} = \mathbb{E}[s_{fjt}]$ is the expected exposure to destination country j and $\phi_{jt} = \mathbb{E}[\text{Exposure}_{fjt} u_{ft}] / \mathbb{E}[\text{Exposure}_{fjt}]$ is the exposure-weighted expectation of unobserved drivers of currency choice.

If we had share exogeneity as in Goldsmith-Pinkham et al. (2020), that is $\mathbb{E}[s_{fjt} u_{ft}] = 0$ then the above would be satisfied for any Δe_{jt} , that is for any distribution of exchange-rate innovations. It is, however, unlikely that firm net currency exposure - itself a function of currency invoicing - would be uncorrelated with unobserved components of the firm currency invoicing decision. Thus, we will in general not satisfy $\phi_{jp} = 0$.

However, Borusyak et al. (2022) provide two conditions under which consistency of the estimator can be proven in absence of shares exogeneity:

1. $\mathbb{E}[\Delta e_{jt} | \phi_{jt}] = \mu \quad \forall t$ (*Quasi-random shock assignment*)
2. $\mathbb{E}[\Delta e_{jt} \Delta e_{jt-l} | \phi_{jt}, \phi_{jt-l}] = 0 \quad \forall l$ (*Many independent shocks*)

The first condition states that more exposed firms should not have a systematically stronger response of the component of currency invoicing choice not explained by I_{ft} . Alternatively, each firm f is expected to face the same shock μ regardless of its ϕ . The second condition requires that we observe a sufficiently long time series of non-serially correlated shocks.

Let us examine how plausible it is that these two conditions hold. The unpredictable behaviour of exchange rates, together with the length of our sample make condition (2.) plausible. Condition (1.) is supported by the fact that the first large shock in our sample is driven by the election result, well before the realisation of any fundamental shock. Furthermore, UK firms' exposure to dollar funding is not large, in line with other European counterparts (BIS, 2020). In addition to this, two observations are in order. First, we partially relax the two conditions by including firm and time fixed effects. Adding α_f eliminates time-varying unobservables from ϕ_{jt} , so that exchange rate shocks can systematically correlate with time-invariant unobservables without violating the exclusion restrictions. By adding δ_t to the specification we allow for period specific shock means, that is μ can become μ_t . Secondly, we hold exposure shares fixed to a pre-shock period, namely 2015. As shares are likely to be affected by lagged shocks and shocks might be serially correlated, this is a way for the *quasi-random shock assignment* condition to be satisfied, by measuring the shares from a period before the serially correlated period starts.

2.3.2 Dynamic event-study analysis

We also estimate the fine-grained dynamic effects of currency mismatch exposure on invoicing decisions relying on the following specification at the fpj (firm-product-destination) level and at monthly frequency:

$$y_{fpj,t} = \alpha_{fpj} + \delta_t + \sum_{m \neq \text{Jan } 2016} [\beta_m (s_{f,2016}) \times \mathbf{1}_{m=t}] + \epsilon_{fpj,t} \quad (2.3.2.1)$$

where $y_{fpj,t}$ is again the share of exports by firm f of product p to destination j invoiced in GBP, δ_t is a time fixed effect, α_{fpj} is a firm-product-destination fixed effect and $\mathbf{1}_{m=t}$ is an indicator equal to 1 in month m and 0 otherwise. $s_{f,2016}$ is a special case of the more general $s_{f,t}$, defined as

$$s_{f,2016} = \frac{\sum_j [(\mathcal{E}_{fj,2015}^{\mathcal{L}} - \mathcal{I}_{fj,2015}^{\mathcal{L}}) \times \Delta e_{j,2016}^{\mathcal{L}/j}]}{Total\ Trade_{f,2015}} \quad (2.3.2.2)$$

where we fix the exposure at the 2015 (pre-shock) level and we interact it with the 2016 depreciation. As FX movements took place already prior to the post-referendum depreciation, we take $\Delta e_{j,2016}^{\mathcal{L}/j}$ to be the average of the monthly movements between January 2016 and June 2016, but results are robust to using only June 2016. In sum, this measure captures the intensity of the shock suffered by a firm f around the event in 2016. Finally, we also conduct robustness estimating separately the share of 2015 imports in GBP and the share of 2015 exports in GBP, rather than $s_{f,t}$ net exposure. We show that both these gross margins matter individually.¹¹

Identification

We are interested in isolating the potential effects of the Brexit-related depreciation in 2016 through the hedging channel described above. We thus rely on the unexpected nature of the outcome of the referendum for the exogeneity of the exchange-rate shock considered. The (continuous) treatment is provided by the heterogeneous incidence of this shock on UK firms based on their pre-shock net exposure to GBP, as captured by higher and lower levels of $s_{f,2016}$.

We sharpen this identification by saturating the regression with firm-product-destination and time fixed effects, and by focusing on a narrow window for exchange-rate movement going from January to June in 2016. We thus check in the next section for any pre-trend and anticipation effects, although Brexit was a largely unexpected outcome.

2.4 Main Results

2.4.1 Static regression analysis

The results from Equation 2.3.1.1 are presented in Table 2.1. First, we notice that more exposed firms decrease their GBP invoicing share. Intuitively, an opposite effect of similar magnitude, albeit slightly larger, is found for USD invoicing. Third, the effect on the euro is smaller and slightly less significant.

¹¹See Appendix B.2.

Table 2.1: Results from baseline specification.

	Value share of exports in					
	GBP	GBP	USD	USD	EUR	EUR
	(1)	(2)	(1)	(2)	(1)	(2)
<i>Panel a. Baseline specification</i>						
Valuation shock $s_{f,t}$	-0.01*** (-6.37)	-0.01*** (-6.02)	0.007*** (4.73)	0.01*** (4.82)	0.003*** (3.85)	0.003*** (3.13)
<i>Panel b. Strategic complementarities</i>						
Invoicing of largest firm in HS4		0.02*** (16.79)		0.02*** (17.06)		0.02*** (12.60)
Average invoicing in HS4		0.09*** (10.64)		0.09*** (17.06)		0.15*** (8.94)
Additional valuation controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time x Gap FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,322,378	724,482	1,322,378	724,482	1,322,378	724,482

Note. – The coefficients in Panel a. are the β s from the baseline static specification $y_{ft}^h = \beta s_{f,t} + Controls_{f,t} + \alpha_f + \delta_t \times \Delta_t + u_{f,t}$. They show that a firm being 'long' GBP+GBP depreciation drives the firm to reduce its GBP invoicing. In panel b. are the coefficients on the strategic complementarities controls. They indicate that the market leader's decision as well as average sector decision matter.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

How to interpret the magnitude of the coefficients? The valuation shock $s_{f,t}$ is expressed in percentage of gross trade, while the dependent variable is in percentage points. Therefore, a firm long GBP by 100% of its gross trade and facing a 1% GBP depreciation will reduce its pound invoicing by 1 percentage point and shift it towards USD by a similar amount.

These headline results are robust to controlling for the effect of strategic complementarities. Once we account for the currency choice of competitors and market leaders, we find the coefficients do not change and even increase in magnitude in the case of the USD.

Moving to the coefficients on strategic complementarities, we find a role for both the currency choice of the largest player in the HS4 sector, as well as a relevant effect for the average invoicing choice in the sector.

Finally, these results are robust to extending the sample of estimation to include both the Covid and post-Covid period to 2022. Furthermore, we show that our

findings are also robust to using trade quantities instead of values as dependent variable, which rules out a mechanical valuation effect due to the depreciation.¹²

Notice that all the regression outputs considered so far included also controls for the other hedging indices mentioned in Section 2.3.1, and for market power. In the interest of space and clarity, we relegate those results to Appendix B.2 and Section 2.4.4, respectively.

2.4.2 Dynamics

How did this identified currency-mismatch channel unfold over our sample and especially around the large depreciation episode of 2016? We use our specification in Equation 2.3.2.1 to assess this. Figure 2.7 presents the result from the event-study set-up discussed above.

First, notice how GBP invoicing decisions before 2016 appear to be similar for more and less GBP exposed firms, leading us to assess that we do not seem to observe any pre-trend or anticipation effect that could potentially undermine our empirical approach.

Second, taking January 2016 as our reference point for the valuation shock, we observe a marked reduction in GBP invoicing by more exposed firms relative to less exposed firms. The effect of the currency mismatch channel in response to the large depreciation in 2016 seems to build quickly over that year, to then assume a more gradual pace over the more recent part of the sample. Importantly though, its impact appears to be persistent and monotonically dragging on GBP invoicing shares.

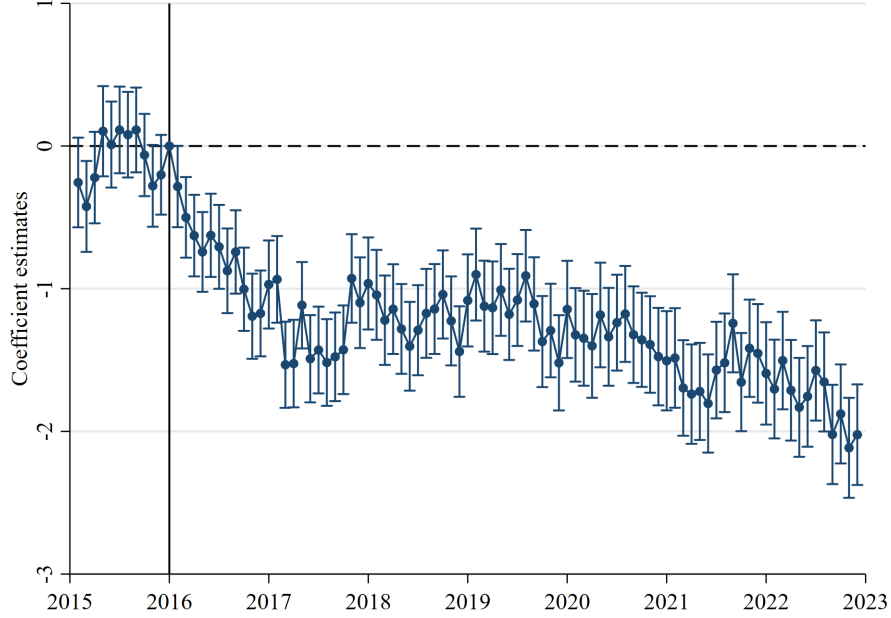
In the Appendix B.2 we include equivalent results for USD and EUR invoicing, showing the expected monotonic boost to invoicing in those currencies.¹³

Furthermore, in the Appendix B.2 we also check whether our results are robust to considering only the share of 2015 imports in GBP or the share of 2015 exports in GBP rather than net exposure. We find that both margins play a role. More

¹²See for more details Appendix B.2.

¹³As well as robustness versions of the three event studies at quarterly rather than monthly frequency.

Figure 2.7: EVENT STUDY: EFFECT OF CURRENCY MISMATCH-WEIGHTED GBP DEPRECIATION ON GBP INVOICING



Note.— The graph plots the coefficients β_m from dynamic specification over time, capturing the differential reduction in GBP invoicing by treated (highly exposed) firms.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

GBP exports as a share of total trade drive a decrease and increase in GBP as opposed to USD and EUR invoicing, respectively. Conversely, more GBP imports lead to an increase in GBP invoicing and a decrease in USD and EUR invoicing. This change of sign of the impact is to be expected: as GBP imports increase, everything else given, then the net exposure becomes more negative and thus the positive coefficient leads to a larger drag on GBP invoicing.

2.4.3 Quantitative importance

Having established the importance of the operational hedging channel in the previous sections, we now turn to assess its quantitative contribution to explain the novel stylised fact in Figure 2.1 motivating our analysis.

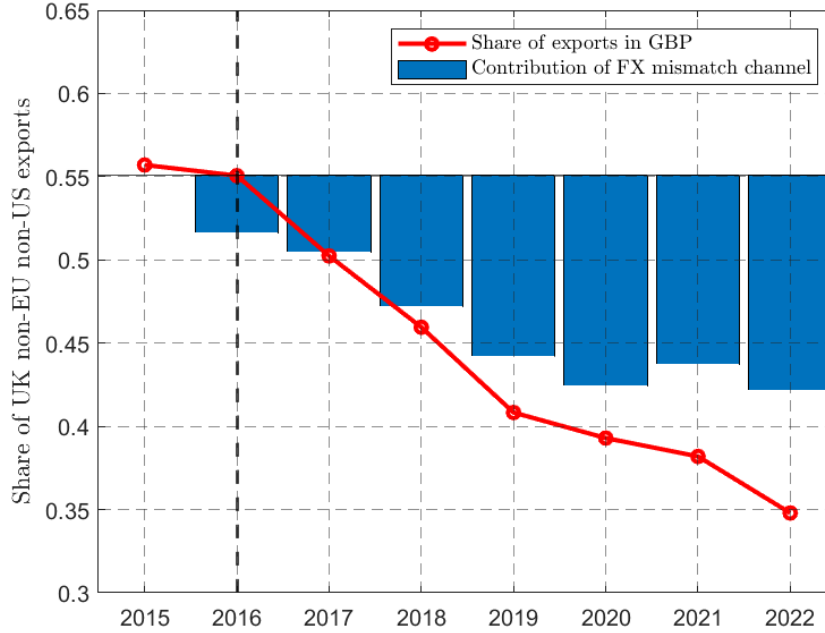
To do this we perform a simple back-of-the-envelope calculation underpinned by our baseline event-study results. Our approach follows a three-step procedure. First, we retrieve our estimates for the interaction terms between the month fixed

effects and the GBP exposure pre-2016 from Figure 2.7, and multiply them by the contemporaneous value of the exposure variable. Given the specification of the event study which uses the first month of 2016 as reference point, this allows us to have an estimate of the change in the firm-level GBP invoicing share starting until the end of 2022. Second, we cumulate those changes to the starting GBP share in January 2016 to obtain a monthly counterfactual share, where the change is a function of the currency mismatch channel as captured by our specification (2.3.2.1). Finally, we can multiply these counterfactual shares by the total firm-level exports to have a counterfactual level of GBP for every business, and then aggregate. We can then compare the resulting counterfactual series with the corresponding one from 2.1a, in order to gauge the importance of the channel we have identified for the aggregate change in the UK invoicing shares. Figure 2.8 shows the results of this exercise. We show this at annual frequency in order to speak directly to the main novel stylised fact and motivation in Figure 2.1, and include versions at monthly frequency in Appendix B.2. The hedging channel appears to be able to explain most of the remarkable drop in GBP invoicing observed since 2016. As expected with the stickiness in invoicing decisions from the literature and the lagged responses identified by our own empirical work above, the effect builds gradually together with the aggregate change away from GBP and into USD and, to a smaller extent, EUR.

2.4.4 The role of market power

We have so far analysed the fall in GBP share of UK exports only from the point of view of UK firms. Invoicing decisions, however, just like pricing ones, arise from the interaction of a buyer and a seller. While in the literature the invoicing decision is mainly thought to belong to the exporter, the role of a foreign importer on the UK transition could be ambiguous. On the one hand, there is the convenience of using a vehicle currency given the network of international trade (Gopinath and Stein, 2021). This might mean that importers have a preference for goods being invoiced in USD. On the other hand, an importer's situation vis-a-vis the Brexit shock is the mirror image of that of its UK counterpart: as the GBP depreciates,

Figure 2.8: CURRENCY MISMATCH CHANNEL: CONTRIBUTION TO AGGREGATE SHIFT IN GBP



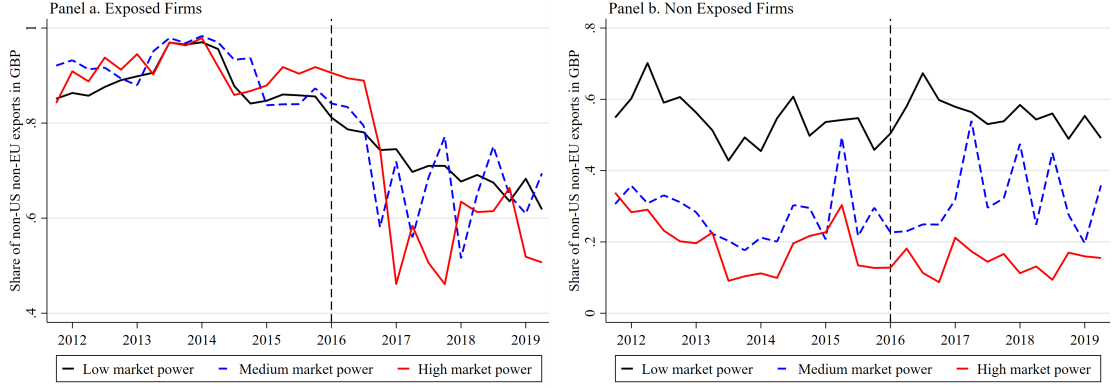
Note. – The red line is the aggregate share of exports invoiced in GBP as in Figure 1, and the blue bars show how much of the dynamics of the red line can be explained by the dynamic hedging channel.

Source: HMRC administrative datasets, UK non-EU exports, 2010–2022.

this implies an immediate discount on the importer’s purchases. As the GBP may be expected to weaken further, this might make GBP invoicing desirable in the eyes of foreign customers. We could expect that importers would at the margin prefer to continue being invoiced in GBP. If this was the case, the outcome we observe might be driven by firms with high market power succeeding in imposing a shift in invoicing patterns towards a ‘harder’ currency.

We thus investigate this channel by considering a simple measure for firm-level market power commonly used in the trade literature (Crowley, Han and Prayer, 2023), namely a firm’s market share for a certain product in a given destination. We collect total imports by origin country, destination country and 6-digit product classification from UN Comtrade. We can compute destination j ’s UK share of imports for product p ,

Figure 2.9: GBP INVOICING BY GBP EXPOSURE AND MARKET POWER



Note. – Firms are divided into three market power quantiles based on their market share in each product-destination market. Then, aggregate GBP share of exports analogous to those in Fig.1 are plotted for each quantile. In red are firms with high market shares, in dashed blue medium, and in black firms with low market shares. This exercise is conducted separately, considering only firms with above the median (Panel a.) and below the median (Panel b.) $Exposure_{f,t}$.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

$$UK\ Share_{pj,t} = \frac{\mathcal{I}_{pj,t}^{UK}}{\sum_{all\ origins} \mathcal{I}_{pj,t}^i} \quad (2.4.4.1)$$

Similarly, from the microdata we can construct the UK market share of a firm for product p and destination j

$$Firm\ share_{fpj,t} = \frac{\mathcal{E}_{fpj,t}}{\sum_{all\ UK\ firms} \mathcal{E}_{fpj,t}} \quad (2.4.4.2)$$

where, of course, $\sum_{all\ UK\ firms} \mathcal{E}_{fpj,t} = \mathcal{I}_{pj,t}^{UK}$. We can then combine the two to obtain a firm's market share $\omega_{fpj,t}$ in a given destination and product market

$$\omega_{fpj,t} = Firm\ share_{fpj,t} \times UK\ Share_{pj,t} \quad (2.4.4.3)$$

With these measures at hand, we can then divide firms by percentiles of market share to identify three groups: low (below the 75th percentile of the distribution of market shares), medium (between the 75th and 90th percentile) and high (above 90th percentile) market power firms.¹⁴ Figure 2.9 shows the evolution of GBP

¹⁴See Figure B.5.

invoicing shares by these groupings, separately for exposed ($s_{f,t}$ above median) and non-exposed ($s_{f,t}$ below median) firms.

Two main considerations emerge from inspecting Figure 2.9. First, if UK firms did not suffer from the 2016 valuation shock and therefore had no motive to shift away from the pound, we should not expect to see the significant change in GBP usage from the pre-shock period that we observe in panel a. Second, since we know UK businesses *did* suffer from the valuation shock, then we would expect their market power to matter at the margin to resolve the clash of the two opposing forces described above: (i.) the incentive for UK exporters to operationally hedge more and thus shift to the USD; and (ii.) the motive for foreign importers to keep GBP invoicing on their transactions with UK exports, as foreign buyers might perceive the GBP as a ‘soft’ currency after the large 2016 depreciation. Our results seem to support to some extent this enabling role played by market power, with panel a indeed showing that exposed firms did reduce their GBP invoicing, but to a somewhat larger extent for those with larger market shares.

In the light of this evidence, we test for the relevance of market power formally by estimating specification 2.3.1.1 enriched by our measure of market power $\omega_{fpj,t}$, as mentioned above already included in the control variables.

Table 2.2 reveals a mixed picture on the role played by market power. On the one hand, as expected from the discussion above, our results suggest that higher market share leads to more GBP invoicing and less need to use vehicle currencies. On the other hand, the interaction with the valuation shock is always insignificant, suggesting that during adjustments after valuation shocks the degree of market power might not exert effects over and above its average impact.

We further investigate the potential effects of market power on invoicing by adjusting our event study set-up in Equation 2.3.2.1 to account for it in the following way:

$$y_{fpj,t}^h = \alpha_{fpj} + \delta_t + \omega_{fpj,t} + \sum_{m \neq \text{Jan 2016}} \gamma_m \omega_{fpj,t} \times \mathbf{1}_{m=t} + [\beta_m (\omega_{fpj,t} \times s_{f,t}) \times \mathbf{1}_{m=t}] + \epsilon_{fpj,t} \quad (2.4.4.4)$$

Table 2.2: RELEVANCE OF MARKET POWER.

	Value share of exports in					
	GBP	GBP	USD	USD	EUR	EUR
	(1)	(2)	(1)	(2)	(1)	(2)
<i>Panel a. Baseline specification</i>						
Valuation shock $s_{f,t}$	-0.01*** (-6.37)	-0.01*** (-6.02)	0.007*** (4.73)	0.01*** (4.82)	0.003*** (3.85)	0.003*** (3.13)
<i>Panel b. Strategic complementarities</i>						
Invoicing of largest firm in HS4		0.02*** (16.79)		0.02*** (17.06)		0.02*** (12.60)
Average invoicing in HS4		0.09*** (10.64)		0.09*** (17.06)		0.15*** (8.94)
<i>Panel c. Firm Market Power</i>						
Market Power		0.04*** (5.33)		-0.05*** (-7.67)		0.01 (1.95)
Market power $\times$ valuation shock		0.03 (0.46)		-0.04 (-0.75)		0.03 (1.16)
Additional valuation controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time x Gap FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,322,378	724,482	1,322,378	724,482	1,322,378	724,482

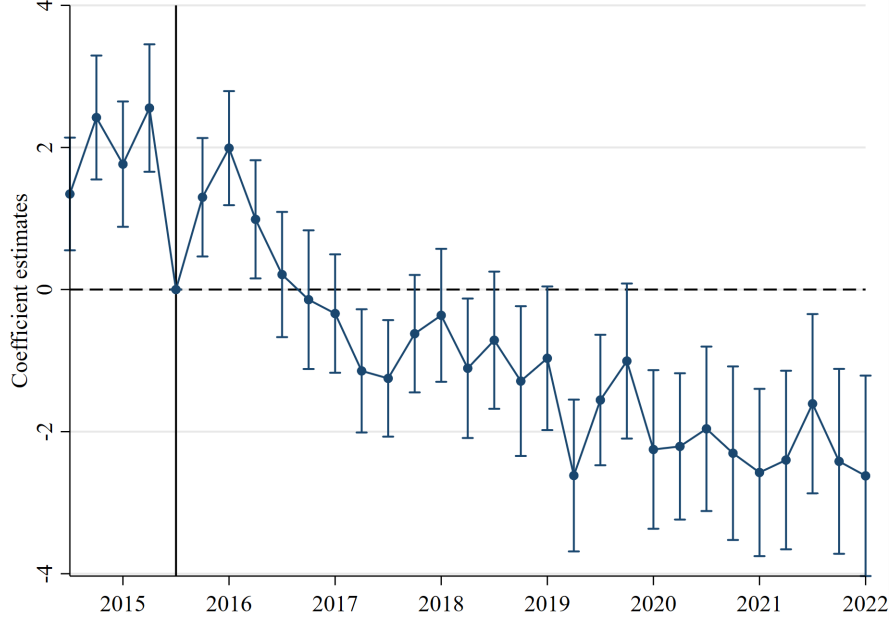
Note. – The coefficients in Panel a. and in panel b. are analogous to those in the previous table. In panel c. are the coefficients on the market share variable $\omega_{fpj,t}$ and on the interaction of market share $\omega_{fpj,t}$ with exposure $s_{f,t}$.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

Figure 2.10 shows the results of estimating equation 2.4.4.4 which exploits the potential variation between the behaviour of exposed firms with high market share vis-a-vis exposed firms with low market shares. The estimation for the coefficients of interest β_m is quarterly to more directly unpack the relationship estimated in the quarterly static regression 2.3.1.1. As it is clear from the chart, only from 2019 onwards we start seeing a gradual and significant reduction in GBP usage by firms with stronger market power.

To conclude, we find mixed evidence on the role played by market power in the determination of invoicing currency. In particular, our results do not seem to consistently support the contribution of this additional channel in combination with the operational hedging motive in response to the 2016 depreciation, to the large shift in invoicing away from the GBP that we documented in Figure 2.1. Having

Figure 2.10: EVENT STUDY: EFFECT OF MARKET POWER AT THE MARGIN WITH HIGH EXPOSURE TO GBP DEPRECIATION.



Note. – The graph plots the coefficients β_m from dynamic specification enriched with market power $y_{fpj,t}^h = \alpha_{fpj} + \delta_t + \omega_{fpj,t} + \sum_{m \neq Jan\ 2016} \gamma_m \omega_{fpj,t} \times \mathbf{1}_{m=t} + [\beta_m (\omega_{fpj,t} \times s_{f,t}) \times \mathbf{1}_{m=t}] + \epsilon_{fpj,t}$ over time, capturing the differential reduction in GBP invoicing by treated (highly exposed) firms which have a relatively higher market share.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

documented and characterised the potential channels behind the sizable reduction in GBP invoicing, we now turn our attention to the macroeconomic implications of this dominant currency pricing transition.

2.5 Macroeconomic implications of dominant currency pricing transition

Amiti et al. (2022) show that a firm’s currency choice has a direct causal effect on the exchange rate pass-through into prices and quantities. Has the structural change in currency choice that we documented in section 2.2 and analysed empirically in sections 2.3 and 2.4 altered this causal link? Are UK exporters more exposed to the dollar cycle now than they were before 2016?

In order to shed light on these questions, we estimate the dynamic responses

of exported quantities before and after the shift. In order to study how export quantities of UK firms respond to USD-destination exchange rate movements, we employ an econometric specification in the spirit of the work by Amiti et al. (2022). It is a two-stage procedure, where a regression of export prices in foreign currency onto exchange rates represents the first stage, while a regression of quantities on (fitted) prices is the second stage. In both stages, we control for detailed firm, destination-product and time fixed effects. We capture the elasticity of quantities to price pass-through of USD exchange rate movements. We compute this dynamic measure for the pre 2016 sample and the post 2016 sample.

2.5.1 Have Allocative Properties of Export Price Rigidity Changed?

Exchange rate pass-through into export prices, or lack thereof, might have a sizeable impact on quantities. For example, suppose a firm exports components with a unit price set in GBP of £100. With full price rigidity, a 1% GBP depreciation vis-à-vis the destination currency will be equivalent to a 1% discount. The extent to which this affects quantities is not obvious, as import-export relationships tend to be recurrent and with long-established partners, so that short-run price changes might not be enough to drive significant shifts in quantities. Furthermore, if we look at aggregate exports, and we acknowledge the shift in invoicing occurred out of the GBP and into the USD, it is interesting to explore whether this affected relative allocative properties of pass-through across the two currencies of invoicing. Namely, we would expect that quantities respond via price rigidity more strongly to movements in the USD exchange rate than before 2016.

In order to test this hypothesis, we adopt a two-stage empirical specification akin to Amiti et al. (2022), where the first stage is

$$p_{f pj, t+h}^* - p_{f pj, t-1}^* = \beta^h \Delta e_t^{\$/j} + \alpha_j + \delta_{pj} + \nu_t + u_{f pj, t} \quad (2.5.1.1)$$

where the dependent variable is the change in log unit prices expressed in foreign currency between period $t + h$ and $t - 1$ for firm f selling product p

to destination j and $\Delta e_t^{\$/j}$ is the change in the log exchange rate between the USD and the currency of destination j . We introduce firm, time, and product-destination fixed effects. Thus, the main source of variation is the time series changes in the USD/destination exchange rates. We could also introduce firm-destination-time fixed effects, which would absorb exchange rate fluctuations and would rely on cross-sectional difference (say, invoicing) as source of identification. But we have already tested this dimension in our previous econometric specification. Here, instead, we are interested in the dynamic change in elasticity and are thus interested in the variation at the firm-destination-time level. After estimating (2.5.1.1), we employ the fitted values in

$$q_{f pj, t+h} - q_{f pj, t-1} = \theta^h \Delta_{t-1} \hat{p}_{f pj, t+h}^* + \alpha_j + \delta_{pj} + \nu_t + u_{f pj, t} \quad (2.5.1.2)$$

where the dependent variable is the change in log quantities between period $t + h$ and $t - 1$ for firm f selling product p to destination j , and $\Delta_{t-1} \hat{p}_{f pj, t+h}^*$ is the fitted value from the first stage. We estimate this specification for the pre-2016 and post-2016 period¹⁵ and obtain the results in Figure 2.11, plotted alongside 95% confidence intervals, based on standard errors clustered at the firm-product-destination level. We find that, as intuition would suggest, the elasticity is always negative. This considerably increases in magnitude going from the pre-2016 period (blue line) to the post-2016 sample (red line), where after 4 months it stabilises around 1 in absolute value.

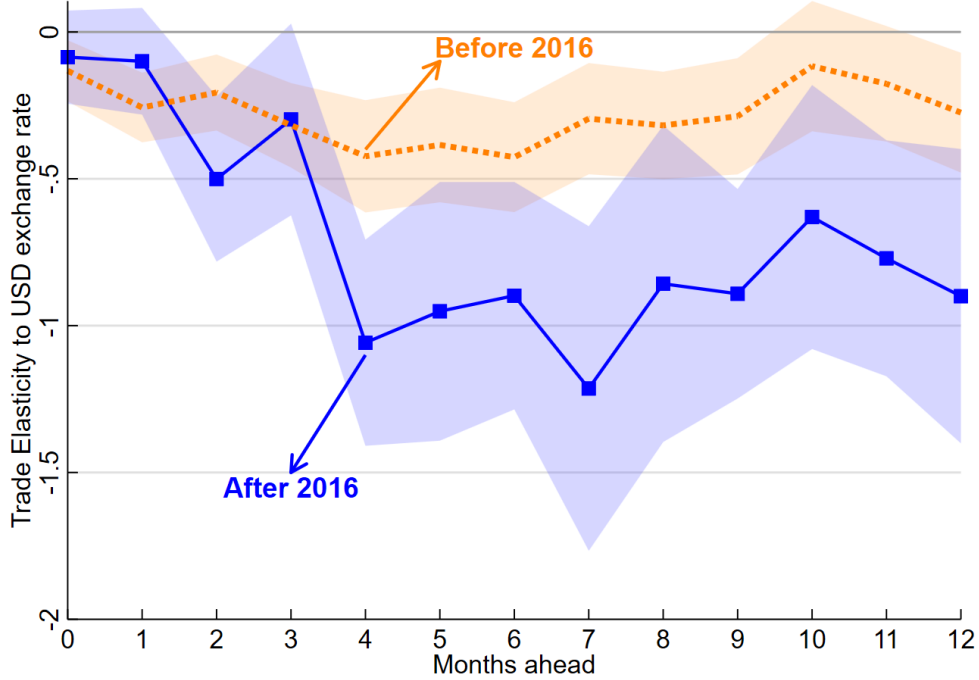
In conclusion, our additional empirical analysis finds that the elasticity of export quantities to USD exchange rate movements doubled from the pre-2016 to the post-2016 period, both in the short and medium run.

2.6 Conclusion

In this paper we use transaction-level data on the universe of imports and exports for UK firms to document a striking fact about aggregate currency invoicing: a

¹⁵Observations for the year 2016 are excluded from both samples.

Figure 2.11: DYNAMIC ELASTICITY OF EXPORT QUANTITIES TO APPRECIATION OF USD.



Note. – The two lines represent the dynamic elasticities of UK export quantities to movements in USD exchange rates, in blue for the pre-2016 (pre transition) period and in red for post-2016. The line in red is by month 4 almost twice as large in absolute value as the blue line, indicating that a USD appreciation depresses UK exports by more than twice than before 2016.

Source: HMRC administrative datasets, UK non-EU exports, 2010–2019.

dominant currency pricing transition. We show how UK exports, dominated by producer currency (GBP) invoicing pre-2016 have shifted to dominant currency paradigm after the large GBP depreciation in the aftermath of the EU referendum. More than half of extra-EU exports are now invoiced in USD. We exploit this unique setting to investigate the causal effect of currency-mismatch valuation effects on invoicing decisions. We show that, in the presence of operational currency mismatches, a large, unexpected shock to the level of the exchange-rate can generate a rapid aggregate change in invoicing currency patterns.

Our paper therefore speaks to the debate on the outlook for dollar dominance. The post-Brexit dollarisation of UK exports provides an important counter to the de-dollarisation narrative that has taken ground following the Russian invasion of Ukraine. It shows that further margins of increase in US dollar dominant currency

pricing still exist, even outside of emerging markets. That said, the rapid shift we document confirms the insights of the historical literature on dominant currencies. Shocks can rapidly alter the usage of international currencies and force a transition from one equilibrium to another. This is true even in the present-day context where network externalities in the international monetary and pricing system have been shown to be pervasive. In particular, our results raise the question of the potential consequences of unexpected, large downward movements in the USD for global dollar dominance.

The dollarisation of UK exports also had first-order macroeconomic implications. We show that the causal effect of firm-level invoicing choices - on aggregate exchange-rate pass-through and the allocative effects of price rigidities - evolves in line with changes in the basket of invoicing currencies. Compared to the pre-Brexit referendum period, UK exports are now twice as sensitive to USD exchange rate movements. This *Dominant Currency Pricing Transition* therefore made the UK economy more exposed to US and global spillovers. This could have important consequences in terms of domestic monetary policy and its independence from global forces (Miranda-Agrippino and Rey, 2022), as dollarisation might mute its transmission channel through the exchange rate, and thus potentially alter normative considerations on the optimal conduct of policy. We plan to investigate these in future work.

3

Greenback?

Sustainable Investing and the International Transmission of Monetary Policy

This paper studies how US monetary policy shocks affect foreign firms depending on their carbon emissions. Combining high-frequency monetary surprises with firm-level data for about 5,000 non-US firms across 38 countries, I show that US monetary tightening disproportionately impacts higher (“brown”) relative to lower (“green”) emitters: investment, debt, and equity prices decline more sharply, while bond spreads rise more for firms with higher carbon intensity. To rationalise these findings, I develop a model featuring a global sustainable investor with (i) limited risk-bearing capacity for transition-risky assets and (ii) preferences for holding green securities. Both channels imply that tighter US monetary policy widens the return differential between brown and green assets, and thus disproportionately decreases capital and investment for brown firms, in line with my empirical evidence. As both channels operate in the same direction, this leads to an identification challenge, which I overcome by matching granular investor-firm data for

I am thankful to Andrea Ferrero and Francesco Zanetti for their support and guidance. I am also grateful to Tommaso Bighelli, Martin Bodenstein, Lukas Boehnert, Davide Brignone, Ambrogio Cesa-Bianchi, Pasquale Della Corte, Maarten De Ridder, Julian di Giovanni, Francesca Diluiso, Aydan Dogan, Sarah Duffy, Sergio de Ferra, Thomas Grjebine (discussant), Marcin Kacperczyk, Óscar Jordà, Vladimir Otrachshenko (discussant), Pablo Ottonello, Alba Patozi, Rick van der Ploeg, Sanjay Singh, Roger Vicquéry and Emilio Zaratiegui for their valuable comments and suggestions. I would like to thank for helpful discussions the participants to seminars at the 3rd International Conference on the Climate-Macro-Finance Interface, 7th EMME Workshop Emerging Market Macroeconomics at CEPII, ESCB Research Cluster Climate Change, Maastricht University, University of Oxford and Bank of England. All errors and omissions remain my own. The views expressed in this paper are those of the author and not necessarily those of the Bank of England and its committees.

US global funds' holdings and the universe of syndicated lending to non-US borrowers. I identify the risk-bearing channel by estimating US spillovers holding investors' preferences constant while exploiting variation in firms' carbon intensity; and vice versa for the preferences channel. Through this strategy, I find support for both channels. My findings suggest that emission-dependent monetary spillovers can make greener countries more resilient to US spillovers, while browner ones, commonly emerging economies, are penalised.

JEL Codes: E52, F34, F41, F42, G12, G14, G15, G30

3.1 Introduction

As evidenced by a rich literature in international economics, the impact of US monetary policy interventions does not remain confined to national borders, but reaches other economies, independently of their own domestic policy actions (Miranda-Agrippino and Rey, 2020; Rey, 2015). For instance, when the Federal Reserve increases interest rates, this worsens not just US but also global financial conditions, thereby depressing asset prices and lending, and so ultimately leading foreign firms to reduce their investment (Elliott, Meisenzahl and Peydró, 2024; Bruno and Shin, 2015). However, not all firms are affected in the same way: both the closed- (Ottonello and Winberry, 2020; Jeenas, 2018; Cloyne, C. Ferreira et al., 2019; T. R. T. Ferreira et al., 2023) and open-economy (Hegarty et al., 2023; di Giovanni and Rogers, 2022; Kalemli-Ozcan, 2019) literature highlight several sources of heterogeneous spillovers, for example firms' financial position and credit risk. By showing how US monetary policy shocks differentially affect higher and lower emitters abroad, my paper uncovers a new source of heterogeneity, namely corporate carbon emissions. As the world continues its steady transition to a low-carbon economy, understanding the nature of this differential effect will become increasingly important, as more firms weigh the benefits of greening their production processes and supply chains. This especially so in a time of higher interest rates across the world, which many economists argue may slow down the green transition,

given the larger and higher-risk capital costs associated with the development of renewable energy infrastructure and associated R&D (Schnabel, 2023).

This paper makes three main contributions. First, I combine micro-data on corporate financial and real outcomes, including firm-level emissions, for approximately 5,000 companies across 38 advanced economies and emerging markets over the period 2010-2019, to document heterogeneous spillovers of US monetary policy on foreign higher — brown — and lower — green — firms. Following a contractionary shock by the Federal Reserve which tightens its monetary policy stance, (i) foreign brown firms see their equity prices fall by more than their green counterparts; (ii) the spreads on their corporate bonds increase, while (iii) their debt and (iv) investment decline by more. Second, to rationalise my findings, I build a novel model of a global sustainable investor allocating capital across brown and green assets. Crucially, to match my newly documented evidence, this international intermediary exhibits two key features. First, they have preferences for green over brown assets. Second, they have lower risk-bearing capacity for holding brown as opposed to green securities, as the former are riskier due to their exposure to transition risk, that is future cash-flow losses from potential policy and technological innovation linked to the global move to a low-carbon economy. The model reveals that both channels lead to the same disproportionate increase in spreads of, and thus decreased investment in, brown with respect to green assets. Thus, each on its own can rationalise the heterogeneous responses from my empirical evidence. Third, to overcome this identification challenge and disentangle the effects of the two channels, I merge granular data at investor-firm level. This allows me to focus on the risk channel by zeroing in on investors with the *same* preferences but with *different* carbon exposures through their holdings. Conversely, keeping the carbon intensity of the corresponding firm fixed by looking at the *same* security held by investors *across* preferences for green assets, I successfully parse out the effect of preferences. To this end, using the universe of US global funds' holdings and international syndicated loans, I find evidence for both mechanisms being at play. Following an exogenous policy tightening by the Fed, US funds with a

sustainability mandate, i.e. Environmental, Social, and Governance (ESG) funds, pull more capital away from brown than green investments abroad. Preferences for green assets do play a role as well: comparing ESG and non-ESG funds' capital outflows within the same security following US tightening reveals that the divestment from brown assets is larger for sustainable funds. I find a similar role for preferences in debt markets: syndicated lenders that have made climate commitments to greening their portfolios cut credit to non-US brown borrowers by more than they do to green ones. Taken together, my results suggest that the adverse effects of US spillovers might be amplified for brown firms and thus by extension more carbon-intensive economies, typically emerging markets, which thus stand to be disproportionately penalised by the financial channels I have uncovered, while greener economies might benefit in the form of additional resilience.

My first step in this paper is to document novel heterogeneous responses to US monetary spillovers by foreign firms depending on their carbon emissions. This is a necessary precursor, as the existing literature is unable to provide a widely agreed prior hypothesis on how corporate emissions might affect the international transmission of monetary policy. On the one hand, several studies have uncovered large heterogeneity in the sign and magnitude of firm-level responses to *domestic* monetary policy driven by businesses' features such as size (Gertler and Gilchrist, 1994), age (Cloyne, C. Ferreira et al., 2019), liquidity holdings (Jeenas, 2018), default risk (Ottonello and Winberry, 2020) and excess bond premia (T. R. T. Ferreira et al., 2023), as well as to *foreign* shocks whose effects might be modulated through the degree of corporate involvement in international trade and financing (di Giovanni and Rogers, 2022; Di Giovanni and G. Hale, 2022; Gopinath and Itskhoki, 2022; Kalemli-Ozcan, 2019; Miranda-Agrippino and Rey, 2020; Miranda-Agrippino and Nenova, 2022; De Leo et al., 2023; Hegarty et al., 2023; Adams and Verdelhan, 2022). If any of these corporate features were clearly correlated with green or brown status, I could use the existing body of literature to formulate an expected relationship between international spillovers and firms' emissions. However, my novel dataset of non-US firms constructed from several sources and

spanning 38 countries, including 21 advanced and 17 emerging economies, over the sample period from 2010 to 2019, does not suggest substantial heterogeneity along these dimensions: firms directly producing fewer GHG emissions as a share of their sales — i.e. those with lower *carbon intensity*, a common definition of corporate “greenness” in the literature — are no more likely than brown firms to be significantly younger, larger, hold more liquidity, materially riskier, selling or investing more, or relying relatively more on US Dollar funding.

Thus, without an established result from the literature to guide my analysis, I proceed with investigating heterogeneous responsiveness between brown and green firms. My empirical strategy relies on estimating how the dynamic path of firm-level outcomes of interest varies for firms that are more or less brown, i.e. that have higher or lower levels of carbon intensity. I use local projection methods (Jordà, 2005) to do this. Specifically, I regress the variables of interest on the interaction between monetary policy shocks and carbon intensity. This approach allows for the inclusion of comprehensive and tight controls such as time fixed effects, which strengthen identification (Choi et al., 2024).

I proceed as follows. First, I look at how US spillovers might have differential effects on the financial conditions faced by green and brown firms, that is I look at the responsiveness of their asset prices such as equity prices and corporate bond spreads. Second, I investigate whether heterogeneity in transmission to asset prices results in heterogeneous effects on firms’ quantities, such as their debt and investment.

Using a procedure commonly employed by the recent literature on the domestic effects of monetary policy on brown and green firms (Patozi, 2023; Döttling and Lam, 2023; Michael D Bauer et al., 2024), I estimate the heterogeneous effect on non-US stock prices and the credit spreads of corporate bonds to US monetary policy shocks using panel regressions considering the days of FOMC policy announcements. Specifically, using high-frequency policy surprises from Jarociński and Karadi (2020) as proxies for monetary policy shocks on those days, I run panel local projections for the cumulative changes in each asset price with respect to

the day before the announcement, on the interaction between the shock and firm-level carbon intensity. This high-frequency approach is able to mitigate the risk of aggregation bias that can arise when interest rate surprises need to be combined for empirical analysis at lower frequencies (Ramey, 2016). Furthermore, although the surprise measures are designed to be exogenous, analysing daily fluctuations through this method reduces the likelihood of reverse causality, whereby asset-price movements might influence policy shocks (Anderson and Cesa-Bianchi, 2024). I strengthen my specification further by including fixed effects for currency, country, 2-digit NAICS sector and day of announcement, as well as at stock and bond level. Finally, I include controls specific to the asset price considered, as well as known determinants of firm-level heterogeneous responses to monetary policy, such as firm size, age, profits, leverage, default risk, sensitivity to the business cycle (Ottonello and Winberry, 2020), and debt denomination (Gopinath and Itskhoki, 2022; Mukhin, 2022), which help isolate the effect of carbon intensity.

For stock prices, I find that they decline by more for browner firms than green ones following a surprise hike. Specifically, for a one standard deviation higher carbon intensity, stock prices decline by about 2 percentage points more in the two-week period following an announcement, than the average fall of around 10% over the same period triggered by a US monetary policy shock of 25 basis points. Furthermore, by running a battery of robustness exercises and extensions, I find my results to hold when considering the “median rotation” alternative of the surprises by Jarociński and Karadi (2020), other measures of carbon emissions, whether emissions data are estimated, and groups of countries such as advanced economies and emerging markets. My estimates do not show a pre-trend, while there is some evidence of non-linear dynamics across carbon quintiles and comparing the stronger effects of positive as opposed to negative shocks.

For spreads on corporate bonds, I similarly find that non-US brown firms are more adversely affected by a Fed hike compared to non-US green firms. Indeed, for a one standard deviation higher carbon intensity bond spreads increase over a two-week period by about an additional 10 basis points over and above the average rise

of around 8 basis points triggered by a US monetary policy shock of 25 basis points. Also in the case of corporate bonds are my results robust to the tests mentioned above, but I find evidence of non-linearity only for positive shocks leading to a stronger impact than negative ones.

Does this disproportionate tightening of financial conditions translate into differential effects on brown and green firms' activities? I find that the significance of carbon intensity as a critical factor in determining non-US firms' reaction to Fed's monetary policy changes extends to "quantities" and real outcomes. Aggregating monetary policy surprises at a quarterly frequency, I find that both debt and investment decline after an exogenous tightening by the Fed, with brown firms exhibiting greater sensitivity to these shocks compared to their green counterparts. Looking at a period of twelve quarters, for a one standard deviation higher carbon intensity, debt as a share of total assets declines 2 percentage points more than the average reduction of around 4% following an exogenous hike of 25 basis points. Over the same period and following the same shock, investment — defined as the cumulative change in the capital stock — of firms with a one standard deviation higher carbon intensity declines by 5 percentage points more than the average fall between 5 and 10%. Importantly, I include the same firm-level controls as in the previous exercises with asset prices. To further address potential sources of confounding factors, I include firm and country-sector-time fixed effects in all specifications. Finally, my findings pass the same robustness tests as above, but there is no evidence of non-linearity across quintiles of carbon intensity.

The second building block of my analysis involves shedding light on the mechanisms behind this empirical evidence, in order to understand how emissions might matter over and above known drivers of heterogeneous response to US monetary policy.

The burgeoning literature on climate finance (Giglio et al., 2021; Pástor et al., 2024) highlights two main considerations which are at the heart of sustainable investing. First, all investors, not only green-conscious ones, might want to hedge potential future cash-flow losses on their portfolios stemming from climate risk.

The latter includes physical risk (Kruttli et al., 2025), such as floods and other natural disasters¹, and transition risk from climate policies, financial regulatory interventions and technological innovation brought about by the global transition towards a low-carbon economy. These financial motives translate in the practice of “pricing” climate risk, i.e. investors requiring compensation in the form of higher returns for holding browner and thus riskier assets. Equivalently, *investors have lower risk-bearing capacity for brown assets.*² Second, sustainable investing is also about non-pecuniary motives in the form of commitment to greening, and thus *preferences for holding sustainable assets over and above financial considerations.* In equilibrium, investors pricing climate risk or with a preference for green assets will require compensation for holding other assets: this leads to the emergence of a carbon premium in asset prices (Pástor et al., 2021).

Against this backdrop, how do monetary spillovers interact with pricing transition risk, and with green preferences? To find this out, I build a model of a global sustainable investor exhibiting both lower risk-bearing capacity for brown assets and preferences for green assets.

My framework is purposely stylised, in order to highlight the intuition beyond the mechanisms. It spans only one period, from time 0 to 1. At the beginning of time 0, the investor is equipped with net worth and deposits to allocate to holdings of two assets: green and brown securities bought at time 0 for a given price and paying out a return at time 1, which is certain. Since the period ends in time 1, the investor gives her profits, that is the return from holdings net of the return paid on deposits, to households, who proceed to consume all their resources. There are thus neither deposits nor holdings left at time 1. Hence, investors try to maximise their profits in 1 by choosing their holdings at time 0.

I expand on this transparent framework by introducing the two channels described above in the form of two frictions.

¹While this source of risk is not the focus of my paper, I note that my analysis does control for this across specifications with sets of granular fixed effects.

²I thus model risk via lower pledgeability in the leverage constraint of an investor, rather than through the more complex set-up with uncertain pay-offs.

First, at time 0 investors can choose to liquidate or not. If they do, their depositors are left with a smaller portion of brown than green assets. That is, brown assets are less pledgeable because they are more exposed to transition risk. Following the literature (Diluiso et al., 2021), I introduce this in the form of an incentive-compatibility constraint à la Gertler and Karadi (2011) with different weights on green and brown assets. As expected, this friction leads to a carbon premium in equilibrium. However, following a US monetary policy shock, proxied by an increase in the return on deposits in my stylised framework, this carbon premium increases as worsened financial conditions tighten the incentive-compatibility constraint, making it more difficult for her to hold riskier assets such as brown securities. This could be thought of as an extension of the well-established risk-taking channel of monetary spillovers (Bruno and Shin, 2015). As the Fed increases interest rates, global financial conditions tighten, and the net worth of financial intermediaries deteriorates, leading them to have a lower risk-bearing capacity; this, in turn, results in higher spreads and cost of financing for riskier firms. As in this set-up investors price climate risk over and above usual credit default considerations, this mechanism strengthens, leading to what Altavilla et al. (2024) have referred to, in the context of domestic monetary policy, as a *climate* risk-taking channel of monetary policy.

Second, at time 0 investors obtain direct utility (Krishnamurthy and Vissing-Jorgensen, 2012) from holding green as opposed to brown assets. As a result of this entering the maximisation problem of the investor, a carbon premium emerges in equilibrium — this time generated by a bias in the investor’s attitude towards assets with specific characteristics. What happens when the Fed tightens policy? This second channel is more mechanical. As the Fed increases interest rates, pulling capital flows back to the US and away from foreign investments, an investor with a bias towards green assets will divest by less from those securities. This means that investors’ preferences lead to higher (lower) capital outflows for brown (green) firms in response to US monetary spillovers, echoing what Patozi (2023) finds in the case

of domestic monetary policy. Thus, the spread demanded to hold brown over green assets will also increase, similar to what happens through the risk-bearing channel.

Crucially, while rooted in different micro-foundations, both mechanisms operate in the same direction. They amplify (attenuate) the worsening of financial conditions for foreign higher (lower) carbon emitters following a US tightening. In turn, this leads to the heterogeneous responses in terms of companies' financing and investment documented by my empirical evidence.

This similarity in results represents, however, an identification challenge when it comes to identifying which channel is at play, and thus behind my documented findings. I resolve this identification challenge as my third and final step.

The empirical challenge of disentangling the effect of climate preferences from that of hedging transition risk requires the use of data sources combining both investor and company information. Looking at how investors with the same preferences allocate capital to companies with different emission profiles, is key to pin down the influence of the risk-bearing channel. On the other hand, considering how investors with non-sustainable preferences compare to sustainable ones can shed light on the role of preferences.

Specifically, I proceed with looking at the universe of US global mutual funds and their quarterly holdings of foreign securities. I first focus on funds with ESG mandates to control for the effects of green preferences. I then run within-fund local projections exploiting the variation in emission intensity across equity holdings. I find that US global sustainable mutual funds exhibit a higher outflow from browner than greener foreign firms after an exogenous hike by the Fed. This result is consistent with a climate risk-taking channel of monetary policy operating independently from green preferences of investors. Expanding the same dataset to include other holders of the same securities as well, but without an explicit ESG mandate, allows me to test for a concomitant preference channel. I indeed find that, looking within security holdings and controlling for both fund and company-specific shocks over time through fixed effects, US global ESG mutual funds pull more capital from browner than greener foreign firms *compared* to non-ESG funds

after a US tightening shock. Furthermore, I find that, after an exogenous tightening by the Fed, mutual funds decrease their shares of firms from the top 2 brown quintiles, as expected given their lower risk-bearing capacity for those assets. In addition, there seems to be a concomitant reallocation towards relatively greener assets, again in line with what would be expected through the risk-bearing channel of monetary spillovers.

The salience of the preference channel extends to debt markets. For this analysis, I combine insights from the literature linking dynamics in the syndicated loan markets to climate considerations (G. Hale et al., 2024; Ehlers et al., 2022; Beyene et al., 2021; Benincasa, 2021; Alves et al., 2024), and the transmission of monetary policy (Elliott, Meisenzahl, Peydró and Turner, 2022; Elliott, Meisenzahl and Peydró, 2024; Lee, 2025). I consider the universe of syndicated lending to non-US borrowers, and identify lenders that have made pledges to green their portfolios (Bolton and M. Kacperczyk, 2025), and in particular banks which are signatories of the SBTi (M. T. Kacperczyk and Peydró, 2022), PRI, TCFD and PRB (G. Hale et al., 2024).³ Including tight fixed effects to control for lender and borrower-level factors in my estimation, I find stronger (weaker) divestment⁴ from brown (green) companies by lenders with green commitments in response to an exogenous US monetary tightening — another evidence of the preference channel being at play. Furthermore, I find that loan tenor to brown borrowers does not shorten after the shock. Because risk-management considerations would normally prompt a maturity reduction, the absence of such an effect reinforces the interpretation that lenders' divestment reflects non-pecuniary screening.

Taking stock, my results imply that the adverse effect of US spillovers might be amplified for brown firms and thus by extension more carbon-intensive economies, typically emerging markets — and precisely those needing more support to catch up and accelerate their climate transition — which stand to be penalised more

³These initiatives are respectively the Science Based Targets Initiative, Principles for Responsible Investment, Task Force on Climate-related Financial Disclosure, Principles for Responsible Banking.

⁴In this context, divestment refers to curtailing new lending rather than secondary-market sales.

by the channels I have uncovered, while greener economies might benefit in the form of additional resilience to monetary shocks. A comprehensive assessment of the economic magnitude of these mechanisms for US spillovers on foreign economies, and spillbacks onto the US, would require the use of a quantitative general equilibrium model, which I leave to future research.

Related Literature With this work I build on and contribute to three main strands of the literature.

First, my work is closely related to the strand of the literature in international macroeconomics and finance which investigates the international spillovers of monetary policy. The seminal work by Rey (2015) found that economies which are open to international capital flows are inevitably exposed to external shocks, even if they let their currencies' exchange rate float. Monetary contractions by the Fed are particularly powerful given the centrality of the US in the international monetary and financial system: they induce co-movements in international financial variables, the so-called "Global Financial Cycle", in turn leading to retrenchments of international credit flows (Miranda-Agrippino and Rey, 2020; Miranda-Agrippino and Nenova, 2022; Georgiadis and Jarocinski, 2025; Bruno and Shin, 2015). These international monetary spillovers are of prime importance for smaller and developing open economies where their effects are most pronounced. Indeed, in response to a surprise monetary tightening, international investors, particularly more active ones, rebalance their portfolios away from emerging markets (Faia et al., 2025). Against this backdrop, a literature has developed examining the heterogeneous effects of international spillovers of US monetary policy on firms, highlighting transmission mechanisms through international trade and financial linkages (Kalemli-Ozcan, 2019; di Giovanni and Rogers, 2022; Hegarty et al., 2023; Gopinath and Itskhoki, 2022). Within this tradition, my work is, to my knowledge, the first to identify carbon emissions as an independent source of heterogeneous firm-level responses to monetary spillovers. I find that international heterogeneity related to climate issues, already highlighted as a driver of cross-country differences in carbon returns

(Zhang, 2025; Bolton and M. Kacperczyk, 2023) and capital flows (Benincasa, 2021; Benincasa et al., 2022; Laeven and Popov, 2022), affects global monetary spillovers through international investors' preferences and risk-bearing capacity. These mechanisms might ensure relatively more resilience to adverse effects of US spillovers for greener open economies, while at the same time browner economies, typically emerging markets, might be penalised (Bolton, Eskildsen et al., 2025).

Second, there is a burgeoning literature on the relationship between monetary policy and climate change (Abiry et al., 2022; Ferrari Minesso and Pagliari, 2023; Ferrari and Nispi Landi, 2020; Giovanardi et al., 2023; Macaire and Naef, 2021; Mongelli et al., 2022; Muller, 2021; Papoutsis et al., 2022), with a particular focus on the heterogeneous effects of monetary policy on green and brown firms, first classified by ESG scores but now more narrowly identified by corporate emissions (Michael D. Bauer et al., 2022; Benchora et al., 2023; Patozi, 2023; Fornari and Groß, 2024; Havrylchyk and Pourabbasvafa, 2025; Döttling and Lam, 2023; Altavilla et al., 2024; Crosignani et al., 2024; Kansoy and Stasiulaitis, 2025). My paper extends existing studies to the international dimension, considering how green and brown companies might react heterogeneously to cross-border spillovers from US monetary policy. It concludes that the differential responsiveness between green and brown firms, so far documented by several studies only within closed-economy settings, also carries over when considering the international transmission of monetary policy through cross-border financial channels. This is of first order importance for policymakers across the world, particularly those where US spillovers are most pronounced such as small advanced and developing open economies. Furthermore, adopting a cross-country perspective allows me to uncover findings about the transmission of US monetary policy that do not appear to hold domestically. For example, I find that credit spreads on corporate bonds of foreign brown firms increase by more than green ones after a US monetary tightening, unlike for domestic US firms where there does not appear to be a significant difference (Patozi, 2023; Döttling and Lam, 2023).

Third, my work speaks to the rich literature on climate finance (Giglio et al., 2021; Pástor et al., 2024), in particular, how differences in climate policy, e.g. across countries, might affect lending (Basu et al., 2025; Benincasa, 2021; Bolton, Eskildsen et al., 2025). More recently, the literature has looked at this also in the context of financial stability (Chiaramonte et al., 2024; D’Orazio, 2025) and climate stress testing (Cicco et al., 2025; Busies et al., 2024).⁵ As already mentioned, the literature on climate finance centres the discussion on the drivers of sustainable investing around hedging climate risk and green preferences. My work contributes to this debate by providing evidence that both aspects of sustainable investing seem to matter for the international transmission of monetary policy. This appears in line with the constellations of results for Fed policy in the US, which come out in favour of the prevalence of preferences (Patozi, 2023; Benchora et al., 2023) or risk (Döttling and Lam, 2023), and for ECB policy within the EU where both channels seem to matter in the context of bank lending (Altavilla et al., 2024); but in contrast with evidence by Ehlers et al. (2022), who find that “green” banks do not appear to price carbon risk differently from other banks.

Outline The remainder of the paper is organised as follows. Section 3.2 describes the different datasets I employ in my analysis. Section 3.3 documents new empirical evidence on the heterogeneous response of non-US brown and green companies to US monetary spillovers. In section 3.4 I lay out my model of an international investor pricing transition risk and exhibiting preferences for green holdings. In section 3.5 I identify and provide empirical evidence for the mechanisms in the model. Finally, I conclude in section 3.6 suggesting further avenues for future research.

3.2 Data

I use three main types of data in this paper. The first type is announcement dates and proxy measures of monetary policy shocks for the Fed. Specifically, I deploy

⁵A new strand is also emerging related to the use of “green derivatives” (Saguato, 2023), whose effect and analysis are beyond the scope of my paper.

shock series calculated following state-of-the-art high-frequency identification. The second type is firm-level data on real and nominal variables, such as GHG emissions and investment. The final type is granular financial information on mutual funds holdings and syndicated loans.

3.2.1 Monetary Policy Surprises

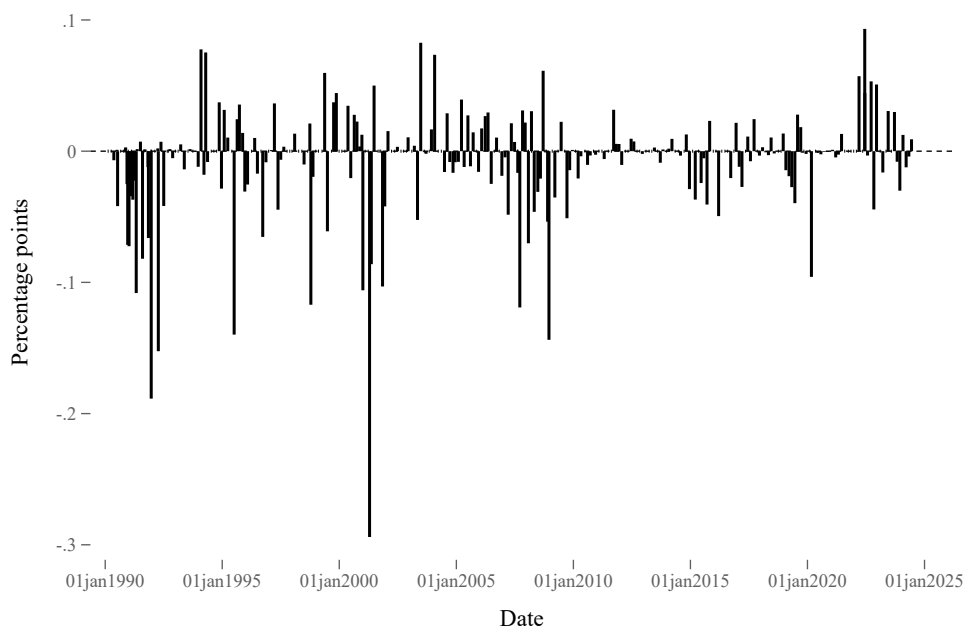
In my analysis I employ shock series from monetary policy surprises for the Fed from Jarociński and Karadi (2020). The authors use high-frequency changes in short-term interest rate derivative prices around FOMC policy announcements to isolate unexpected shocks to monetary policy. They then use information about equity prices to purge these shocks from the effects of information about the economic outlook that is released alongside the policy announcements (Miranda-Agrippino and Ricco, 2021).

A few technical adjustments are worth mentioning here. First, I normalise these series so that they can be interpreted in terms of basis points changes of the selected rate of reference for my analysis: these are the daily yields for the one-year constant-maturity US Treasury (Figure 3.1). Finally, for my analysis at lower frequencies, I aggregate the daily shocks into quarterly series using a simple sum.

3.2.2 Firm-Level Information

I construct a novel dataset linking together information on firm-level emissions, balance sheets including currency of liabilities, corporate bonds and stock prices. I consider only observations dated from 2010 and before 2020, in order to ensure that my results are not driven by the Global Financial Crisis or the Covid-19 pandemic. As highlighted by Döttling and Lam (2023), this is also a period during which climate change concerns enjoyed greater salience and better emissions data coverage, making it an ideal time span for my analysis. I retain publicly listed companies. I exclude all those that (i) are no longer in operation, (ii) whose country of incorporation or listed address is the United States, (iii) is a tax haven according to Hines (2010), (iv) whose headquarters location and country of incorporation are

Figure 3.1: Monetary policy surprises on Fed announcement dates



Notes: Monetary policy shocks for the period 2010 to 2019, normalised so that one unit corresponds to a 1 percentage point change in the market yield on US Treasury securities at 1-year constant maturity. The shock series is based on the “Poor Man’s” high frequency monetary policy surprises robust to information effects from Jarociński and Karadi (2020).

not the same, and (v) for which the currency of document is not the domestic currency of the country in which the firm is located and incorporated (Adams and Verdelhan, 2022).

In addition, I carry out a series of adjustments common in the corporate finance literature, in particular studies using firm-level information to investigate issues in international macroeconomics and finance (Hegarty et al., 2023; Adams and Verdelhan, 2022). I exclude firms in utilities, finance and insurance, real estate and public sectors⁶, which are likely to be too idiosyncratic to be treated in this general framework of analysis. I also exclude the energy sector⁷, as I do not want my results to be driven by the frequently extraordinarily high levels of carbon

⁶For primary NAICS 2-digit sector codes: 22, 52, 53 and 92, respectively. For more details on NAICS classification, see here. Within the remaining sample, I also excludes firms assigned according to Trucost’s simple industry classification to Banks, Capital Markets, Consumer Finance, Electric Utilities, Financial Services, Gas Utilities, Independent Power and Renewable Electricity Producers, Insurance, Multi-Utilities, Office REITs, Real Estate Management and Development, Water Utilities.

⁷NAICS sector code 21.

emissions these firms account for.

Emissions I source corporate carbon emissions data from Trucost. Trucost’s Environment dataset provides annual global greenhouse gas (GHG) emissions data for around 15,000 of the world’s largest listed companies, which together account for 95% of global market capitalisation.⁸

I drop observations for countries or sectors that have one or no firm in the whole sample, and that have only one firm per year. The broad country and sector coverage of my final sample is reported in Table C.1 and C.2, respectively.

This dataset includes not only Scope 1, which I use in my analysis in line with most of the literature (Döttling and Lam, 2023), but also 2 and 3 indicators. Measures of carbon emissions for Scope 1 include direct emissions from sources that are generated or controlled by the business itself, e.g. from using fuel for machines and vehicles. A company may also be classified as either brown or green based on the indirect emissions it accounts for through its operations. Indeed, Scope 2 measures capture indirect emissions, e.g. from consumption of purchased electricity or heating, while Scope 3 from indirect activities attributable to suppliers.

Other firm-level indicators are available from Trucost, for example detailed information specific to Fossil Fuels and Energy Data. However, given their more limited data coverage, I focus my analysis solely on Scope 1 and 2 carbon emissions. For these and in line with the literature, I produce results identifying brown and green firms by both their level (units) and intensity (units over revenues) of carbon emissions. To be clear, Scope 1 intensity is the main variable used in all baseline regressions, while Scope 2 appears only in robustness checks, while Scope 3 as well as the narrower fossil-fuel indicators are excluded from this empirical work.

Finally, as the dataset is reported by fiscal year, I assign each observation to the relevant calendar year in order to reflect the appropriate time period when matched with the other datasets. I do this by assigning an observation to the previous year

⁸See Appendix C.1 for more details on how Trucost puts together the data.

when the reported period-end date is earlier than July. For firm-year observations that have more than one entry after this adjustment, I keep only the latest one.

Balance Sheet After selecting through the procedure described above a panel of companies from the Trucost database, I source corresponding firm-level quarterly information on a series of variables of interest from Compustat North America for Canada and Global for all other countries other than the US and Canada.

Importantly, the capital stock of a firm is not readily available in Compustat. It must be constructed. I follow the vast literature on this (Salinger and Summers, 1983; Clementi and Palazzo, 2019), and use the perpetual inventory method (PIM) to build the capital stock of each firm in my sample from the book value of tangible capital.⁹

Finally, where required, I turn the variables into real values using country-specific GDP deflators from the OECD.¹⁰

Liabilities I source firm-level outstanding liabilities by currency and debt instrument from S&P Capital IQ (Adams and Verdelhan, 2022; Rodnyansky et al., 2022). The dataset includes active and inactive public and private ultimate-parent companies filing financial statements. As is the case with emissions data, this information is usually available only at an annual rather than quarterly frequency. Liabilities are grouped into Bonds and Notes, Term Loans, Capital Leases and Other Borrowing. I use this data to calculate currency shares of liabilities at firm level, which I use as controls in my empirical analysis in section 3.3.

⁹See Appendix C.1 for more details. Recent studies have started to include also intangible capital in firm-level analyses of the capital stock (Peters and Taylor, 2017), and its response to monetary policy (Döttling and Ratnovski, 2021). Following most of the literature on the heterogeneous response of monetary policy across firms, in particular Ottonello and Winberry (2020), I consider solely tangible capital given the difficulties with dealing with intangible assets data at firm level.

¹⁰See OECD Quarterly GDP and components - expenditure approach - volume and price indices here for more info.

Credit Spreads Following Anderson and Cesa-Bianchi (2024), I examine credit spreads¹¹ derived from daily prices of senior unsecured corporate bonds traded in the secondary market between 2010 and 2019. The sample covers debt issued by non-US listed non-financial corporations. My primary source is the ICE Bank of America Merrill Lynch (ICE BofAML) Global Index System, specifically the Global Corporate Index and the Global High Yield Index. Additional bond-level information comes from Thomson Reuters Datastream.

In line with the literature, I filter my sample by dropping bonds with a face value lower than \$1 mln; with maturity of less than 1 year or greater than 30 years; and where the spread exceeds 3,500 basis points.

My final dataset combines bond-level and firm-level information on FOMC announcement days. The resulting sample spans 64 FOMC announcements from 2010 to 2019, covering 567 bonds across 105 firms (out of the corresponding total of 2,547 and 511, respectively), for a total of 14,891 observations.

Stock Prices I collect information on common stocks from Compustat North America and the Global Security Daily dataset, again taking into account all countries other than the US. For a company with multiple issues of stocks, I keep only current primary issue to represent market data for the company as a whole. I filter out stale price data, and stocks where the first two digits of their ISIN code do not match the ISO code of the firm's country. Finally, I use price-close to compute the daily return as the change in a stock's price on market close of that date compared to the price at close the previous day. Returns are winsorised at 1% level. My final sample covers almost 5000 firms accounting for about 25% of total non-US market capitalisation in 2019.¹²

¹¹Specifically, I use the Option Adjusted Spread (OAS), which measures credit spreads by adjusting for two key factors. First, spreads are calculated relative to risk-free securities with matching cash flows, avoiding bias from mismatched maturities. Second, OAS removes the impact of embedded call options, which can distort bond prices and spreads.

¹²According to the World Bank, global and US market capitalisation in 2019 were about 80 and 35 USD trillions, respectively. Thus the total non-US market capitalisation was around 45 trillions, of which my sample captures around 11 trillions.

In order to draw a better picture of the sample captured by my analysis, Table 3.1 summarises the main moments of the relevant variables constructed through matching all these different sources using Capital IQ’s unique firm-level identifiers.¹³ A few important findings emerge.

First, there is a large variation across the sample for several variables. For example, the mean age of a firm is relatively mature, around 60 years, but the distribution is strongly skewed to the right with some firms even older than 100 years. Similarly, the average firm appears to hold a sizeable share of its balance sheet in liquid assets (about 50% of total assets in current assets, and about 15% in cash and short-term investments), and have only limited leverage (around 25% of total assets). However, there is a long tail of firms exhibiting larger values for liquidity measures and leverage.

Second, these descriptive statistics from my collected dataset do not seem to indicate substantial differences between green and brown businesses along these common dimensions of firm-level heterogeneous response to monetary policy. I define firms as brown (green) if their emission intensity, i.e. GHG emissions relative to sales, is higher (lower) than the country-sector median across all years. Non-US brown and green firms do not appear to differ consistently in terms of age, size, liquidity, risk, sales, investment, or reliance on US dollar or euro financing, particularly considering the corresponding standard deviations of these variables.¹⁴

Given my analysis’ focus on sustainable investing, my baseline approach employs measures of Scope 1 carbon intensity, as these are the ones generally considered by institutional investors to guide their exclusionary screening policies (Bolton and M. Kacperczyk, 2021) and commitment-based initiatives such as SBTi (Bolton and M. Kacperczyk, 2025). However, I show equivalent descriptive statistics for Scope 2 emissions in Table C.3 in the Appendix.

¹³Specifically, I mostly use *gvkey* from Compustat.

¹⁴In particular, I note here a slightly higher distance-to-default for green firms. Recall that all these variables and their interactions with the monetary policy shock are included as controls in all later regressions.

Table 3.1: Summary statistics of main firm-level covariates

All Firms	Mean	Median	S.D.	95th P.	Max	N
Emissions	1270508.79	31753.54	6276984.67	5535853.76	2.11e+08	51379
Emissions/revenues	246.37	22.83	1014.10	1169.77	52940.28	51379
dlnk	0.01	-0.00	0.06	0.10	0.52	85203
Real sales growth	0.02	0.00	0.31	0.38	10.33	82339
Age	59.62	41.00	57.13	157.00	653.00	50560
Real total assets	6.82	6.76	1.79	9.92	12.84	85203
Current assets ratio	0.47	0.47	0.20	0.81	1.00	85203
Leverage	0.26	0.24	0.18	0.54	6.98	85203
d2d	7.69	6.67	5.24	16.90	81.58	59796
Che assets ratio	0.14	0.10	0.13	0.38	0.98	85134
USD share	0.07	0.00	0.20	0.60	1.00	67046
EUR share	0.02	0.00	0.10	0.01	1.00	67046

Brown Firms	Mean	Median	S.D.	95th P.	Max	N
Emissions	2169611.42	78889.55	8403957.95	11704845.28	2.11e+08	26355
Emissions/revenues	436.11	46.42	1379.02	2113.48	52940.28	26355
dlnk	0.01	-0.00	0.06	0.10	0.52	47903
Real sales growth	0.02	0.00	0.31	0.37	10.33	46177
Age	61.59	42.00	59.55	158.00	528.00	25868
Real total assets	6.74	6.67	1.83	9.94	12.84	47903
Current assets ratio	0.46	0.45	0.20	0.80	1.00	47903
Leverage	0.26	0.25	0.17	0.54	4.74	47903
d2d	7.27	6.25	5.05	16.31	55.06	33147
Che assets ratio	0.13	0.10	0.12	0.37	0.97	47858
USD share	0.07	0.00	0.21	0.64	1.00	37693
EUR share	0.02	0.00	0.10	0.00	1.00	37693

Green Firms	Mean	Median	S.D.	95th P.	Max	N
Emissions	323583.84	14686.17	2183363.53	730127.45	52399920.39	25024
Emissions/revenues	46.54	14.03	175.59	139.18	2972.61	25024
dlnk	0.01	-0.00	0.06	0.10	0.52	37300
Real sales growth	0.02	0.01	0.32	0.40	7.09	36162
Age	57.55	40.00	54.41	155.00	653.00	24692
Real total assets	6.93	6.88	1.74	9.87	12.37	37300
Current assets ratio	0.48	0.48	0.21	0.83	1.00	37300
Leverage	0.25	0.23	0.19	0.53	6.98	37300
d2d	8.21	7.21	5.42	17.53	81.58	26649
Che assets ratio	0.14	0.10	0.13	0.39	0.98	37276
USD share	0.07	0.00	0.20	0.55	1.00	29353
EUR share	0.02	0.00	0.11	0.01	1.00	29353

Source: CIQ, Trucost and author's calculations. Notes: Summary statistics of panel of firms from 2010 to 2019. Emission measures refer to Scope 1. Firms are brown (green) if their emission intensity is higher (lower) than country-sector median across all years. Listed variables from top to bottom: emission levels (tCO₂e); carbon intensity (tCO₂e/\$M); log first-difference change in the (real) firm-level capital stock (decimals); log first-difference change in (real) firm-level sales (decimals); age of the firm (years since foundation); log of real total assets; current assets (share of total assets); debt over assets (share of total assets); distance to default (units of firm's value volatility); cash and short-term investments (share of total assets); USD liabilities (share of total liabilities). For all details on these variables and the cleaning procedures applied to construct my final sample, please see Appendix C.1.

3.2.3 Investor-Firm Capital Flows

Finally, I gather granular data on the universe of US global funds' holdings and international syndicated loans to non-US borrowers, in order to be able to identify the two mechanisms behind my new empirical evidence in section 3.5.

Mutual Funds I use the CRSP mutual fund database, which is free from survivorship bias, and includes information on a fund's returns and total net assets, along with data on portfolio holdings, expense ratios, and associated fees, as well as other characteristics, such as its investment objective, fund family, type (e.g., equity, bond, hybrid), and founding date.¹⁵ Given the focus of my analysis, I keep only funds that specialise in international investment, and which hold securities I am able to match to firm-level emissions from Trucost and balance sheet information from Compustat. I follow van der Beck (2023) to identify mutual funds with a “sustainable mandate”. I label a fund as an “ESG fund” if it exhibits at least one sustainability keyword in its name.¹⁶ In so doing, I label 46 of the funds in my final sample as exhibiting green preferences — each of these holding on average around 60 different stocks, for a total of around 2,500 stock holdings.¹⁷ Adding to the sample also non-ESG funds with the same holdings, my final sample encompasses almost 2,000 US global funds holding around 2,500 different stocks over a period spanning from 2010 Q1 to December 2019 Q4.¹⁸ In this latest quarter of 2019, my sample accounts for 0.3 USD trillions, and thus about 5% of the amount outstanding in foreign assets held by all US mutual funds.¹⁹

¹⁵I use this dataset because it covers also non-US assets, while other sources such as the data from 13F holdings for institutional investors considers only US equities.

¹⁶The considered keywords are: Environment, social, governance, green, sustainable, responsible, SRI, ESG, climate, clean, carbon, impact, fair, gender, solar, renewable, ethical, thematic, and conscious.

¹⁷Of these 46 mutual funds, the vast majority (37) are institutional funds, and only 12 of the latter are indexed.

¹⁸Of these almost 2,000 mutual funds (1,915), about two thirds (1,289) are institutional funds, and only 402 of the latter are indexed.

¹⁹See Figure 4 of Cavani et al. (2025).

Syndicated Loans I source lender-borrower-loan-level information on global syndicated loans from Refinitiv LoanConnector DealScan over a sample going from 2010 to 2019. In a syndicated loan transaction, a borrower takes out a “deal” from a group, or “syndicate”, of lenders. This deal includes several loans, called “tranches”.²⁰ The dataset includes quantitative and qualitative information at the lender-borrower-loan level, such as price, amount, purpose and covenants. Total cross-border syndicated lending to non-financial firms represents around three-quarters of the total volume of cross-border bank lending to non-financial borrowers (Doerr and Schaz, 2021). Syndicated loans comprised 30% of total global cross-border debt issuance in 2012q4, and 46% for emerging markets (Elliott, Meisenzahl and Peydró, 2024).

Given my focus on capital flows, I consider new loans rather than the stock, that is at *origination*. Furthermore, as I am interested in international spillovers of monetary policy, I consider only cross-border loans, defined as loans where the borrower and lender are headquartered in different countries (Elliott, Meisenzahl and Peydró, 2024), originated by lenders headquartered across the globe, including the US, to borrowers headquartered outside the US. I drop observations corresponding to countries in tax havens according to the classification by Hines (2010). Following the literature, I perform pro-rata splits whenever exact loan shares by lenders are not available — this has been shown to be a reasonable approximation to the actual split (Doerr and Schaz, 2021; Aldasoro et al., 2022). Given the sporadic nature of syndicated credit generation, I collapse the dataset to the borrower-lender-currency-quarter level. I keep only borrowers I am able to match with my Compustat-Trucost sample using the mapping provided by Chava and Roberts (2008). My final sample contains 623 borrowers, 870 lenders, 55 lenders’ and 46 borrowers’ countries over the period 2010-2019.²¹

²⁰Only few tranches have multiple currencies at the same time: I drop these observations to be conservative.

²¹The sample before merging with Compustat is consistent with Table A1 and A2 of (Elliott, Meisenzahl and Peydró, 2024), and with total amounts by year reported by (Aldasoro et al., 2022).

3.3 New Evidence on Carbon Emissions and the International Transmission of US Monetary Policy

The current literature lacks a clear consensus on the relative sensitivity of brown and green firms to central bank interventions within the *domestic* economy.²² This gap makes it challenging to formulate a definitive hypothesis regarding the *international* transmission of monetary policy. Previous studies have identified significant variability in how firms respond to domestic policy and foreign shocks, influenced by factors such as firm size (Gertler and Gilchrist, 1994), age (Cloyne, C. Ferreira et al., 2019), liquidity holdings (Jeenas, 2018), default risk (Ottonello and Winberry, 2020), and excess bond premia (T. R. T. Ferreira et al., 2023). These responses can also be shaped by a firm’s involvement in international trade and finance (Adams and Verdelhan, 2022; De Leo et al., 2023; di Giovanni and Rogers, 2022; Di Giovanni and G. Hale, 2022; Gopinath and Itskhoki, 2022; Hegarty et al., 2023; Kalemli-Ozcan, 2019; Miranda-Agrippino and Nenova, 2022; Miranda-Agrippino and Rey, 2020).

If there was evidence of a clear correlation between these firm-level characteristics and their green or brown status, the existing literature could have provided me with a prior for a specific relationship between international spillovers and a firm’s emissions. As Table 3.1 in the previous section shows this is not the case, in the remainder of this section I thus proceed with investigating heterogeneous responsiveness between brown and green firms. My empirical strategy relies on estimating how the dynamic path of these firm-level outcomes of interest varies for firms that are more or less brown, i.e. that have higher or lower levels of carbon intensity. I use local projection methods (Jordà, 2005) to do this. Specifically, I regress the variables of interest on the interaction between monetary policy shocks and carbon intensity. This approach allows for the inclusion of comprehensive and tight controls such as time fixed effects which strengthen identification (Choi et al., 2024).

²²Not only the sign and the size, but also the underlying mechanisms behind this relative sensitivity remain unsettled.

I proceed as follows. First, I look at how US spillovers might have differential effects on financial conditions faced by green and brown firms, that is I look at the responses of their asset prices such as equity prices and corporate bond spreads. Second, I investigate whether heterogeneity in transmission to asset prices results in heterogeneous effects on firms' quantities, such as their debt and investment.

3.3.1 Stock Prices

I estimate the heterogeneous effect on stock prices by running the following specification:

$$\ln p_{f,\tau+h} - \ln p_{f,\tau-1} = \beta^h \cdot \varepsilon_\tau^M \times \ln b_{f,t-1} + \gamma^h \cdot X_{f,t-1} + \alpha^h + \delta_f^h + \delta_{c,s,\tau}^h + \delta_{j,\tau}^h + u_{f,\tau+h} \quad (3.3.1.1)$$

where the coefficients of interest β^h measure how the response (cumulative logarithmic difference) to a monetary policy shock ε_τ^M , as measured by the surprise series described in section 3.2.1, of the closing quotes for firm f 's (ordinary) stock price on the day τ of the FOMC announcements and subsequent h business days, with respect to the day before, $\ln p_{f,\tau+h} - \ln p_{f,\tau-1}$, changes across the distribution of firm-level emissions according to selected measure $b_{f,t-1}$ in the previous year $t - 1$ with respect to day τ . If β^h is significantly different from zero, this would be evidence of heterogeneous responses between brown and green firms. I include as controls X , all corresponding to the previous year or quarter with respect to τ according to their available time frequency: the term $\ln b_{f,t-1}$, firms' size (total assets), profits, book leverage, market-to-book ratio, cash, short-term debt, retained earnings, distance-to-default, sales growth, current assets as a share of total, age, a dummy equal one if the firms incurred research and development expenses²³, share of USD and EUR liabilities, logarithm of the capital stock, investment rate, market capitalisation and momentum.²⁴ Because heterogeneous responses might stem from states other than the one I consider, i.e. green status, I include all interactions of those controls

²³This is aimed at controlling for the rise of firms based on intangible capital (Peters and Taylor, 2017).

²⁴Note that, while my baseline does not include dividends per share as control in line with Döttling and Lam (2023), my results are robust to including it for the smaller sample data for that variable is available (Figure C.16).

with the monetary policy shock to avoid potential omitted variable bias (Cloyne, Jordà et al., 2023). I include the interaction of $b_{f,t-1}$ with the previous year's GDP growth by country in order to control for differences in cyclical sensitivities across firms. I also add a constant α , firm δ_f^h , $\delta_{c,s,\tau}$ country-sector-time and $\delta_{j,\tau}$ currency-time fixed effects, where s refers to 2-digit NAICS industry categories. Finally, I also include a dummy for the stock exchange. This set of restrictive fixed effects aims at controlling for time-varying and invariant global, country, currency and sector-related features, e.g. the impact of movements in exchange rates or industry-specific production systems disproportionally requiring certain inputs. Finally, I cluster standard errors at firm and time level to account for correlation within firms and over time.

As mentioned already above, the literature highlights two main benefits of this high-frequency empirical approach to recover heterogeneous responses. First, it mitigates the risk of aggregation bias that can arise when interest rate surprises need to be combined for empirical analysis at lower frequencies, such as quarterly or annually (Ramey, 2016). Second, although the surprise measures are designed to be exogenous and may not require controlling for potential confounding factors, analysing daily fluctuations through this method reduces the likelihood of reverse causality, where market movements might influence monetary policy decisions (Anderson and Cesa-Bianchi, 2024). In the context of green and brown assets, (Patozi, 2023) highlights also that this approach addresses the concern that tighter credit conditions could disproportionally affect green innovation, that is whether a firm is or becomes greener could be an endogenous choice (Aghion et al., 2024).

As my baseline, I plug in equation (3.3.1.1) a standardised version of the Scope 1 emission intensity measure²⁵ from Table 3.1, and estimate the coefficients on its interaction term with monetary policy shocks.

²⁵While total emissions are a crucial metric for society, emissions intensity is arguably a more suitable measure for evaluating the carbon performance of individual firms (Aswani et al., 2024). In the Appendix C.2, I show how my findings are robust to using absolute emissions rather than carbon intensity.

Figure 3.2 plots the results. It shows how brown firms experience a more adverse impact from a 25 basis point exogenous Fed tightening compared to non-US green firms. Specifically, for a one standard deviation higher carbon intensity stock prices decline over a two-week period by about an additional 2 percentage points on top of the average²⁶ decline of around 10% over the same period triggered by a US monetary policy shock of 25 basis points. In the nearer term, i.e. horizon 0 and 1, the magnitudes of the average effect and the additional effect of emissions are in line with the corresponding figures around 4% and 0.4% from the US-only closed-economy literature (Döttling and Lam, 2023), and thus also the amplification’s share of the average effect. Over the days, the average impact builds up, as the effects come in with lags, underlying the potency of US monetary spillovers on the rest of the world (Miranda-Agrippino and Rey, 2020).²⁷

Furthermore, in Appendix C.2.2 I run a battery of robustness exercises. I find my results hold (i) when considering the “median rotation” alternative of the surprises by (Jarociński and Karadi, 2020); (ii) other measures of carbon emissions such as Scope 1 absolute emissions but not Scope 2 carbon intensity, which is unsurprising given that investors tend to focus on Scope 1 measures — for example institutional investors use Scope 1 measures for their exclusionary screening policies (Bolton and M. Kacperczyk, 2021); (iii) excluding emissions data estimated by Trucost and retaining only the ones directly reported by firms, and (iv) groups of countries such as advanced economies and emerging markets, the latter exhibiting double the response of the former. Finally, (v) my estimates do not show a pre-trend.²⁸

²⁶Figure C.4 in Appendix C.2.2 shows this. Notice, in order to estimate the average effect for the regression of the cumulative change on the monetary policy shock on its own, I must drop the time fixed effects and all the interaction terms with the shock.

²⁷Furthermore, when considering the average effect of around 5% for Advanced Economies only — Figure C.5 — it is within the bands estimated for the first-month response of the FTSE All Share and DAX Stock Market to a 25 bps monetary policy shock in the US. See Figure 10 in Miranda-Agrippino and Rey (2020).

²⁸I also find that my results are robust to including firms from the energy sector in my sample (Figure C.17), and excluding firms with listing also in the US or traded in the US through ADRs, which are around 400 out of almost 5000 firms in my final sample (Figure C.18).

I also carry out a series of extensions to test whether my results exhibit any non-linearity. For example, following the literature (Michael D Bauer et al., 2024; Patozi, 2023; Döttling and Lam, 2023) I investigate the potential presence of non-linear effects by sorting firms into quintiles of emission intensity, where I assign each firm to a group if its average Scope 1 emission intensity over the years of my sample falls within that country-sector quintile of the distribution across all years. Figure C.13 reports the results for the estimated coefficients on the interaction terms with quintile dummies, where the base group left out is the first quintile, i.e. the “greenest” firms. The drag for browner firms broadly increases with carbon intensity. However, Figure C.13 reveals this might be happening non-linearly, with firms within the highest two quintiles exhibiting a larger differential reduction than those at lower quintiles. Finally, there is evidence of non-linearity in the effects of positive and negative monetary policy shocks, as I find my results being driven by the former rather than the latter.

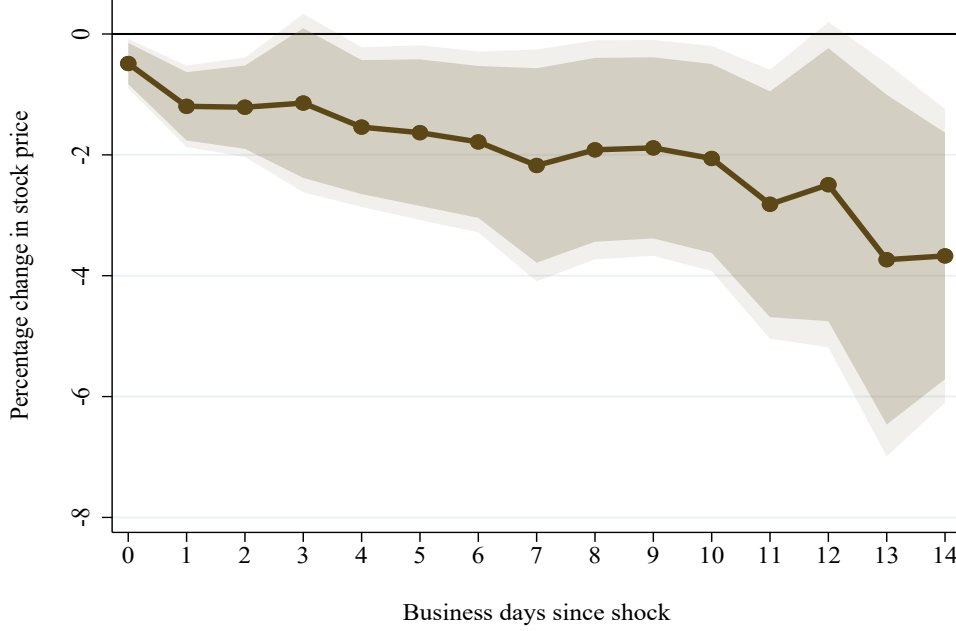
3.3.2 Credit Spreads

I proceed by running the same exercise for corporate bonds’ credit spreads:

$$\Delta cs_{b,\tau+h} = \beta^h \cdot \varepsilon_\tau^M \times \ln b_{f,t-1} + \gamma^h \cdot X_{f,t-1} + \theta^h \cdot Z_{b,\tau-1} + \alpha^h + \delta_b^h + \delta_{c,s,\tau}^h + \delta_{j,\tau}^h + u_{b,\tau+h} \quad (3.3.2.1)$$

where, again, the coefficients of interest β^h measure how the response (cumulative difference) to a monetary policy shock ε_τ^M of the daily spreads for company f ’s bond b on the day τ of the FOMC announcements and subsequent h days, with respect to the day before, $\Delta cs_{b,\tau+h}$, changes across the distribution of firm-level emissions. I include the same firm-level controls X as for (3.3.1.1), while adding bond-specific controls Z , including the (logarithm of the lagged) age of the bond, its remaining maturity, its market value and coupon rate, and a dummy indicating whether the bond is earmarked for a sustainability-related project, i.e. “green bonds” according to the classification by LSEG. The rest of the set-up is the same as for (3.3.1.1), except for the inclusion of bond fixed effects and clustering at bond and time level.

Figure 3.2: Response of non-US stock prices to US monetary policy: Scope 1 emission intensity



Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure 3.3 plots my estimates for 3.3.2.1. Brown firms are more adversely affected by a 25 basis point Fed hike compared to foreign green firms. Indeed, for a one standard deviation higher carbon intensity bond spreads increase over a two-week period by about an additional 10 basis points over and above the average²⁹ rise of around 8 basis points over the same period triggered by a US monetary policy shock of 25 basis points. As all the estimated coefficients in Figure 3.3 are positive and correlated, but their *individual* confidence intervals are large, I report 90% bands testing for *joint* significance (Inoue et al., 2025). As at least one estimate is outside the bands, I can reject the null that all coefficients are zero.

Comparing these results to the literature is more difficult for the lack of a direct comparison in the closed-economy literature for the US. The magnitude of the average effect is smaller than what found by Anderson and Cesa-Bianchi

²⁹See Figure C.19 in Appendix C.2.3.

(2024), while it is in line with what found by Patozi (2023) for Credit Default Swap spreads.³⁰ Interestingly, I do find a large and jointly significant effect from the interaction term on carbon intensity, while the US-focused literature has so far no supporting evidence for this (Patozi, 2023; Döttling and Lam, 2023). This underscores the importance of an open-economy dimension when it comes to monetary transmission and climate considerations.

Appendix C.2.3 shows that these results are similarly robust as the ones for stock prices considering the same tests. Indeed, they hold across country groups, for the alternative shock series and when keeping only reported emissions; they do not exhibit an anticipatory increasing trend. Note my results are even stronger for a measure of absolute Scope 1 emissions. In terms of extension exercises, notice how positive shocks again have a stronger impact than negative ones.

Does this disproportional tightening in financial conditions translate into differential effects on brown and green firms' activities? I now move to investigate whether the significance of carbon intensity as a critical factor in determining non-US asset prices' response to Fed's monetary policy changes extends to foreign firms' "quantities" and real outcomes. I consider two variables central to firms' operations, i.e. their debt and investment.

3.3.3 Debt

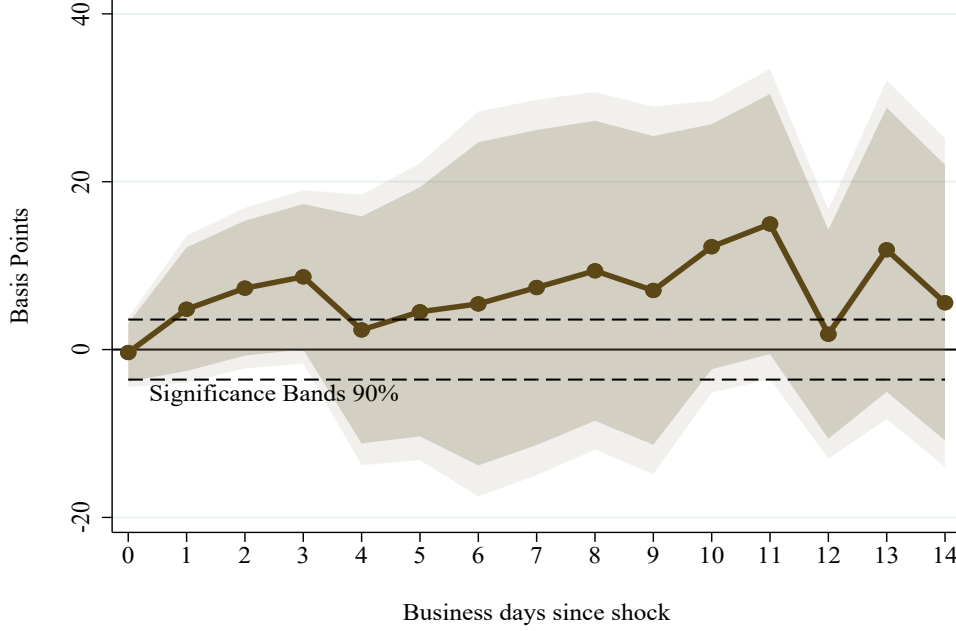
After aggregating the monetary policy surprises series from daily to quarterly frequency, I employ the following empirical specification:

$$\frac{debt_{f,\tau+h} - debt_{f,\tau-1}}{assets_{f,\tau-1}} = \beta^h \ln b_{f,t-1} \varepsilon_t^M + \gamma^h X_{f,\tau-1} + \alpha^h + \delta_f^h + \delta_{c,s,\tau}^h + u_{f,\tau+h} \quad (3.3.3.1)$$

where the coefficients of interest β^h measure how the response of the stock of debt as a share of total assets of firm f from quarter $\tau - 1$ to τ and following periods, $\frac{debt_{f,\tau+h} - debt_{f,\tau-1}}{assets_{f,\tau-1}}$, to a monetary policy shock in quarter τ changes depending on $b_{f,t-1}$ in the previous year $t - 1$ with respect to quarter τ . If β^h is significantly

³⁰Furthermore, when considering the average effect of around 8bps for Advanced Economies only — Figure C.20 — it is within the bands estimated for the first-month response of the UK Corporate Spread and German Corporate Spread to a 25 bps monetary policy shock in the US. See Figure 10 in Miranda-Agrippino and Rey (2020).

Figure 3.3: Response of non-US credit spreads to US monetary policy: Scope 1 emission intensity



Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.2.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level. Significance bands for joint test are constructed using the Wild-Block Bootstrap (Inoue et al., 2025).

different from zero, this would be evidence of heterogeneous responses between brown and green firms. I include the same firm-level controls X as above, as well as the interaction of $b_{f,t-1}$ with the previous year's GDP growth in order to control for differences in cyclical sensitivities across firms.³¹ I add a constant α , firm fixed effects δ_f^h , and $\delta_{c,s,\tau}$ country-sector-time fixed effects, where s refers to again 2-digit NAICS industry categories.³² I include a dummy indicating the fiscal quarter following Ottonello and Winberry (2020). Clustering of standard errors is at firm and time level.

Figure 3.4 reports the estimated coefficients on the interaction terms from

³¹Notice also how the fact that I retain only non-subidiaries incorporated and whose headquarters are located outside the US allows me to control for possible within group exposure to US through ultimate owners located in the US, and thus directly exposed to Fed monetary policy.

³²Caggese et al. (2024) show how the effect of temperature on demand-adjusted productivity varies across sectors, with high capital intensive sectors experiencing larger losses. I note that my sector-time fixed effects controls for these.

(3.3.3.1). It shows how a 25 basis point exogenous hike of the US policy rate disproportionately reduces brown firms' debt compared to foreign green firms. This augments the decrease between 3-4% of total assets experienced by the average foreign firm as a result of the same shock during the first year (Figure C.31), by about 2 additional percentage points, concentrated in the first four quarters following the shock. While direct comparisons to my estimated additional impact are, to my knowledge, lacking, I note here that the latter exhibits a similar magnitude to the extent that firms with high leverage and low distance to default access more external finance — which debt is a component of — following a monetary shock according to Ottonello and Winberry (2020).

In the Appendix C.2.4, I show how these findings are robust to the series of cross-checks I carry out above for stock prices and bond spreads. Notice that the responses based on quintiles exhibit a weak gradient implying little evidence for non-linear effects. In contrast, I find that negative monetary shocks have a stronger effect than positive ones for the response of debt.

3.3.4 Investment

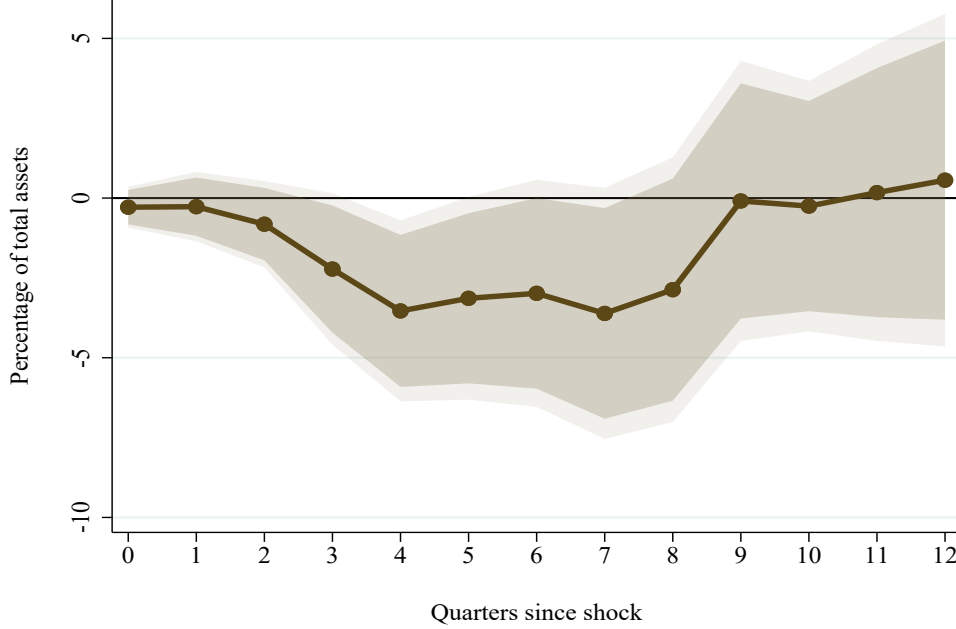
Finally, I estimate the following empirical specification for investment at firm level:

$$\ln k_{f,\tau+h} - \ln k_{f,\tau-1} = \beta^h \ln b_{f,t-1} \varepsilon_t^M + \gamma^h X_{f,\tau-1} + \alpha^h + \delta_f^h + \delta_{c,s,\tau}^h + u_{f,\tau+h} \quad (3.3.4.1)$$

where the coefficient of interest β^h measures how the response of real³³ capital accumulation from quarter $\tau - 1$ to τ and following periods, $\ln k_{f,\tau+h} - \ln k_{f,\tau-1}$, to a monetary policy shock in quarter τ changes across the distribution of firm-level carbon emissions intensity $b_{f,t-1}$ in the previous year $t - 1$ with respect to quarter τ . If β^h are significantly different from zero, this would be evidence of heterogeneous responses between brown and green firms. I include the same list of controls X and fixed effects as for the regressions for debt. Clustering of standard errors is again at firm and time level.

³³I deflate capital by country-specific deflators in order to obtain a real measure.

Figure 3.4: Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity



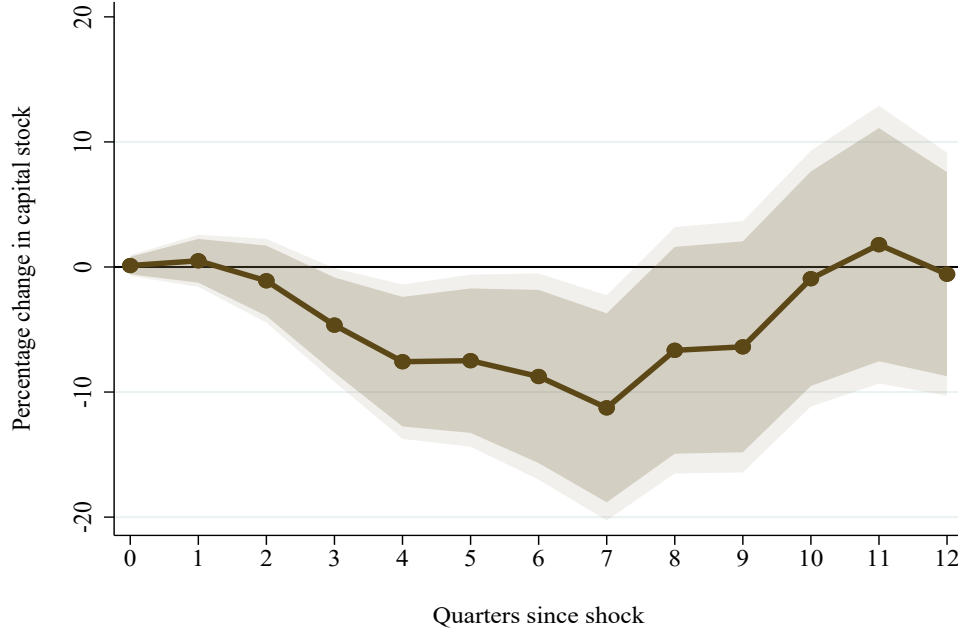
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.3.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure 3.5 reports the estimated coefficients on the interaction terms from (3.3.4.1). It shows how a 25 basis point hike of the US policy rate disproportionately drags on brown firms' investment compared to foreign green firms by about 5 percentage point more for every 1 standard deviation of carbon intensity. This worsens the decrease experienced by the average foreign firms as a result of the same shock (Figure C.42) with investment declining around 5-10% over a twelve quarter horizon.³⁴

In the Appendix C.2.5, I show how these findings hold through the same robustness tests as above. I find no evidence of anticipatory effects, nor non-linearity across quintiles of the carbon intensity distribution. Comparing responses to positive and negative shocks, I find the former to take longer to have an impact

³⁴The magnitude of the average effect is to the lower end, but in a similar space of, the negative impact on US firms of around 2-4% estimated in the literature for an equivalent 25 basis point Fed hike (Patozi, 2023; Ottonello and Winberry, 2020).

Figure 3.5: Response of non-US firm-level investment to a 25 basis point exogenous tightening by the Fed: Scope 1 emission intensity



Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. Connected line reports the estimated coefficient β^h from equation (3.3.4.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

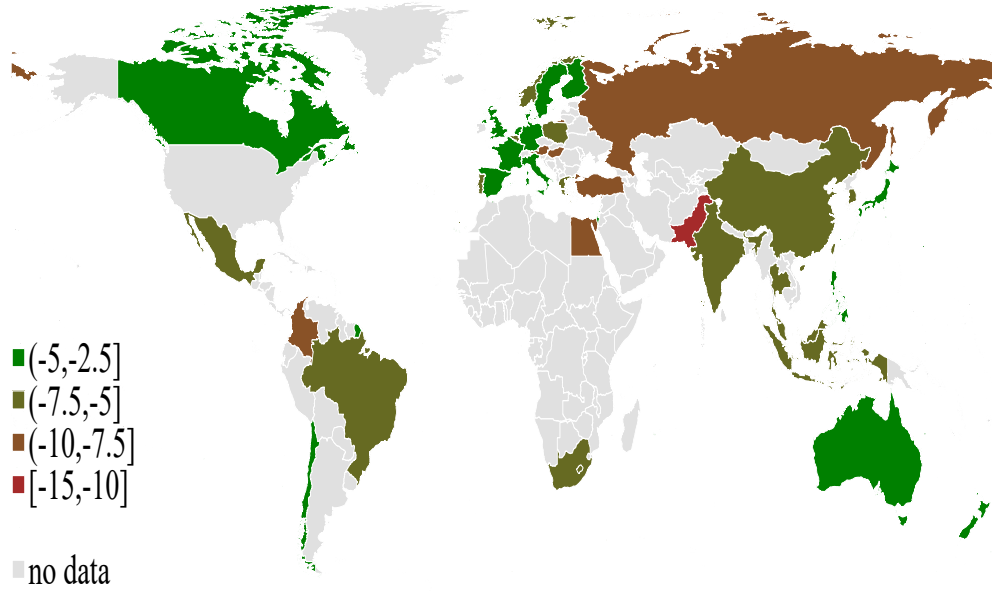
than the latter.

Finally, combining the average and additional impact from heterogeneity in carbon emissions intensity, I can use the data in my sample to construct an expected “aggregate” impact for each country. This is, of course, still a partial equilibrium exercise, given that I am controlling for general equilibrium forces through the fixed effects in my regressions, but it is helpful with providing insights highlighting the importance of cross-country heterogeneity.

For each country in my sample, I plot in Figure 3.6 the sum of the average effect common to all firms, that is a 5% reduction, and the 5 percentage points additional hit multiplied by the average standardised logarithm of carbon intensity for the firms in each country. The Figure shows that the adverse effect of US spillovers might be amplified for brown firms and thus economies, commonly emerging markets — and precisely those needing more support to catch up and accelerate their

climate transition — while greener economies appear more resilient.³⁵

Figure 3.6: Response of country-level investment to a 25 basis point exogenous tightening by the Fed: Scope 1 emission intensity



Notes: Total percentage reduction in investment from average and the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. Average values by countries used in calculations. I include all the countries available in my final sample, and of course exclude the US.

What mechanisms might be behind all my findings? I explore this in the next section.

3.4 A Stylised Model of Global Investors with Climate Risk and Green Preferences

My results from the previous section provide evidence that corporate emissions matter *over and above* known drivers of heterogeneous response to US monetary policy.

To uncover the related channels that might explain this, I look at the literature on climate-related financial issues, i.e. “climate finance”, which has been growing rapidly over the past decade (Giglio et al., 2021; Pástor et al., 2024). This body of

³⁵A comprehensive assessment of the economic magnitude of these mechanism for US spillovers on these economies, and spillbacks on the US, would require the use of a quantitative general equilibrium model, which I leave to future research.

work suggests that the key to explaining my results might lie in the behaviour of sustainable investors.

While only a relatively recent phenomenon, and despite the latest undermining actions of anti-green movements worldwide, *sustainable investing*, i.e. the consideration of financial and non-pecuniary criteria such as environmental metrics in capital allocation, has become a feature of international finance. Tens of trillions of US dollars worth of assets are managed by private investment companies with sustainability commitments³⁶ (Pástor et al., 2024); and many public institutions have been spearheading the development of environmental and climate risk management.³⁷

Two specific features of these investors are of particular interest here.

First, investors care about hedging climate risk. This is the risk of future cash-flows losses on assets exposed to physical risk, i.e. floods and natural disasters made more frequent by climate change, and transition risk, i.e. policy, regulatory, and technological innovation risks resulting from the global move towards a lower-carbon economy. While I control for the former in my analysis, I focus on the latter as that is the one related to corporate carbon emissions. If investors consider brown assets riskier, that is they *price* transition risk, they would exhibit a lower capacity to hold brown assets and bear their risk compared to safer green assets.

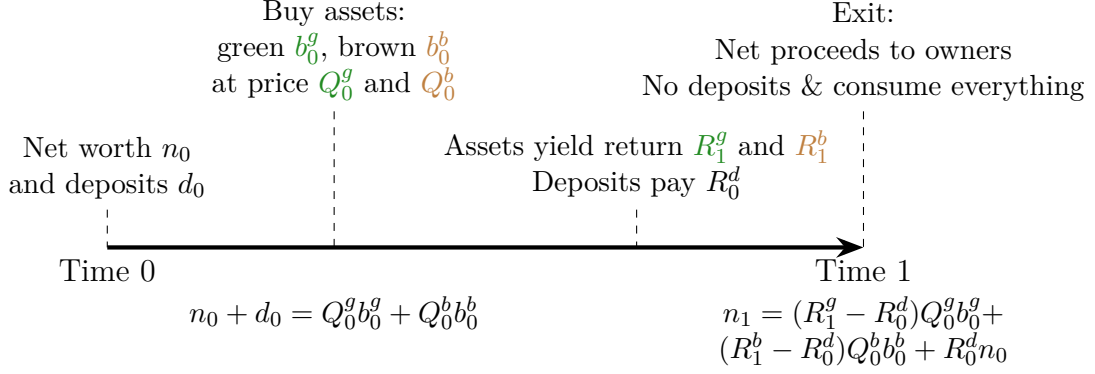
Second, sustainable investors exhibit preferences for holding green assets. This means that, over and above considerations of hedging the relative higher risk of brown as opposed to green assets, investors want to hold disproportionately fewer brown assets for non-pecuniary reasons. The latter are for example encoded in practice in exclusionary and screening strategies based on environmental metrics (Pástor et al., 2024).

Both features lead investors to require compensation for holding brown assets. In equilibrium, this leads to a carbon premium (Pástor et al., 2021), which has been evidenced in empirical studies looking at different asset categories (Giglio et al., 2021), particularly equity (Bolton and M. Kacperczyk, 2023).

³⁶Such as signatories of the Science Based Targets Initiative.

³⁷For example, central banks in the context of the Network for Greening the Financial System.

Figure 3.7: The Model at a Glance



The literature is, however, silent about the potential interaction of monetary spillovers with these channels linked to sustainable investing. I thus proceed to include these two channels sourced from the climate finance literature into a simple macro-finance model. This allows me to draw conclusions on how the transmission of monetary policy spillovers changes when these two mechanisms are taken into account.

3.4.1 Model Set-Up

Figure 3.7 provides a birds-eye view of my model. It spans one single period going from time 0 to time 1. There is no aggregate or idiosyncratic uncertainty. At time 0, a global investor sources financing through initial net worth n_0 and deposits d_0 from her household owners. At time 1 deposits pay R_0^d ; this return proxies for global financial conditions and US monetary policy in my simple set-up. As at time 1 the world ends, the global investor does not retain any holdings and exits giving net proceeds to her owners, who consume them and do not hold deposits any more.

At time 0 the global investor decides how much to buy of two assets: green b^g and brown b^b securities. These are bought, respectively, at price Q_0^g and Q_0^b , and yield return R_1^g and R_1^b at time 1. The balance sheet identity at time 0 is thus $n_0 + d_0 = Q_0^g b_0^g + Q_0^b b_0^b$ and, given the assumptions above, net worth at time 1 is given by $n_1 = (R_1^g - R_0^d) Q_0^g b_0^g + (R_1^b - R_0^d) Q_0^b b_0^b + R_0^d n_0$.

As is common in macro-finance models, the global investor chooses the level of her holdings of the two assets to maximise her discounted sum of future net worth in all periods — in this case just from time 1 as net worth at time 0 is given. There are two important additions to this set-up, however, reflecting the two mechanisms suggested by the climate finance literature described above.

First, the global investor receives direct utility $f(b_0^g)$ from green holdings (Krishnamurthy and Vissing-Jorgensen, 2012). For simplicity of exposition here I assume linear preferences $f(b_0^g) = \zeta Q_0^g b_0^g$, while I show that my analytical results below go through in a more general set-up in Appendix C.3. This first friction implies that the investor seeks to maximise her discounted sum of future net worth *and* utility stream from green holdings in all periods:

$$\max_{b_0^g, b_0^b} \quad \zeta Q_0^g b_0^g + \frac{1}{R_0^d} \left\{ (R_1^g - R_0^d) Q_0^g b_0^g + (R_1^b - R_0^d) Q_0^b b_0^b \right\} \quad (3.4.1.1)$$

Second, at time 0 the investor can choose to liquidate or not their position and stop operating. If she does, her depositor owners are left with a fraction $1 - \theta$ of brown and $1 - \theta\Delta$ of green holdings, where $0 < \theta < 1$ and $0 < \Delta < 1$. This means that, for the investor to keep operating, her continuation value of discounted future utility and profits must always exceed the value of the share of her portfolio that she would be able to take from her depositors, that is $\theta Q_0^b b_0^b + \theta\Delta Q_0^g b_0^g$. This is formalised by the following incentive-compatibility constraint common in models of financial frictions (Gertler and Karadi, 2011), and recently also employed by quantitative studies in the space of climate macroeconomics (Diluiso et al., 2021):

$$\zeta Q_0^g b_0^g + \frac{1}{R_0^d} \left\{ (R_1^g - R_0^d) Q_0^g b_0^g + (R_1^b - R_0^d) Q_0^b b_0^b \right\} \geq \theta Q_0^b b_0^b + \theta\Delta Q_0^g b_0^g \quad (3.4.1.2)$$

Intuitively, this framework is a convenient and tractable way to capture heterogeneous risk-bearing capacity of investors across brown and green assets. Indeed, Δ captures the fact that transition (credit) risk makes brown assets less *pledgeable* in case of liquidation.

The maximisation problem of the investor thus takes into account both these frictions, and consists in choosing the level of green and brown holdings at time 0 which maximise (3.4.1.1) subject to (3.4.1.2).

Solving this problem and combining the FOCs for each security³⁸, when the constraint binds — that is when its Lagrangian multiplier $\lambda > 0$ — yield the following equilibrium condition:

$$R_1^b - R_1^g = \left\{ \underbrace{\frac{\lambda\theta(1-\Delta)}{1+\lambda}}_{\text{Risk-Bearing}} + \underbrace{\zeta}_{\text{Preference}} \right\} R_0^d \quad (3.4.1.3)$$

The relationship defined in (3.4.1.3) shows that in equilibrium a spread between the return on brown and green assets emerges. This carbon spread, or *premium*, has been shown by several studies in the literature to exhibit large variation across types of assets and economies (Giglio et al., 2021).

Taking stock, the model yields the following conditions, which are individually sufficient for a carbon spread in equilibrium:

Proposition 1 *In equilibrium, brown securities must yield a higher return than green ones, that is the carbon spread is positive, when $0 \leq \Delta < 1$, i.e. there is differential risk-bearing capacity across brown and green assets.*

Proposition 2 *In equilibrium, brown securities must yield a higher return than green ones, that is the carbon spread is positive, when $\zeta > 0$, i.e. investors have preferences for green holdings.*

Crucially though, notice how my simple model makes clear that the premium might arise from both the friction linked to the lower risk-bearing capacity for brown assets of investors, as well as their preference for green assets.³⁹ As Δ decreases, that is as brown assets become less pledgeable, investors demand a larger compensation to hold those assets relative to green ones. This translates into a higher spread in equilibrium. Furthermore, as investors' green bias gets stronger, i.e. as ζ increases, the carbon spread becomes wider in equilibrium as well.

³⁸I relegate all derivations and details to the more general version of my model, described in Appendix C.3.

³⁹This echoes the same result from the model by Pástor et al. (2021). Their model is, however, more complex as it uses a mean-variance set-up, and it does not explicit the role of monetary policy. This is why I favour the described set-up for my analysis, while acknowledging that a suitable extension of their model could deliver similar results in terms of both the risk and preference channels affecting the transmission of monetary policy.

3.4.2 Sustainable Investing and Monetary Policy Spillovers

I now move to use the model to understand the effects of monetary policy spillovers. I do this by considering the case of US monetary policy tightening interest rates and in turns global financial conditions, proxied in my simple set-up by an increase in the financing rate of the global investor R_0^d .

Computing the derivative of the carbon spread with respect to the deposit rate, I obtain the following expression⁴⁰:

$$\frac{\partial(R_1^b - R_1^g)}{\partial R_0^d} = \frac{\lambda\theta(1 - \Delta)}{1 + \lambda} + \zeta > 0 \quad (3.4.2.1)$$

The result in (3.4.2.1) shows that an increase in the cost of funding for the global investor, for example due to US monetary tightening, leads the carbon spread to increase, as indicated by the positive sign of the derivative.

Thus, my framework leads to the following:

Corollary 1 *When $0 \leq \Delta < 1$, i.e. there is differential risk-bearing capacity across brown and green assets, US monetary spillovers shocks increase the carbon spread.*

Corollary 2 *When $\zeta > 0$, i.e. investors have preferences for green holdings, US monetary spillovers shocks increase the carbon spread.*

Intuitively, as financial conditions tighten because of the Fed's hike, investors must be compensated for the additional pressure on bearing riskier brown assets and holding them instead of the preferred green assets. The carbon spread thus increases, as documented by my results from Figure 3.3. As brown returns increase by more, their prices go down by more (Figure 3.2), and capital gets reallocated disproportionally away from brown assets (Figure 3.4), leading brown firms to be more constrained and decrease their investment by more (Figure 3.5). My stylised model is thus able to match qualitatively my results from section 3.3.

⁴⁰Note that when the incentive-compatibility constraint binds, λ is constant and thus does not vary with R_0^d .

Crucially, from the model I deduce an important takeaway: both mechanisms might be responsible for the patterns I document with my empirical evidence. This thus represents a substantial challenge when it comes to identifying which channel is at play.

Despite this issue, whether it is the climate-risk taking channel or the green preference one that operates, and to what extent, is of first-order interest and thus worth investigating. For example, this might be relevant for the period following the climate transition: if preferences account for my empirical results, the amplification effects penalising brown assets I documented might persist; should it stem from transition risk, it would naturally be expected to dissipate as the world would have transitioned to a low-carbon economy, and the heterogeneous effect of international monetary spillovers with it. Relatedly, new anti-climate stances might affect this amplification mechanism of international monetary spillovers, if it relies on preferences as opposed to risk-taking.

In the next section, I thus disentangle the two mechanisms by tackling this identification challenge with matched granular investor-firm data.

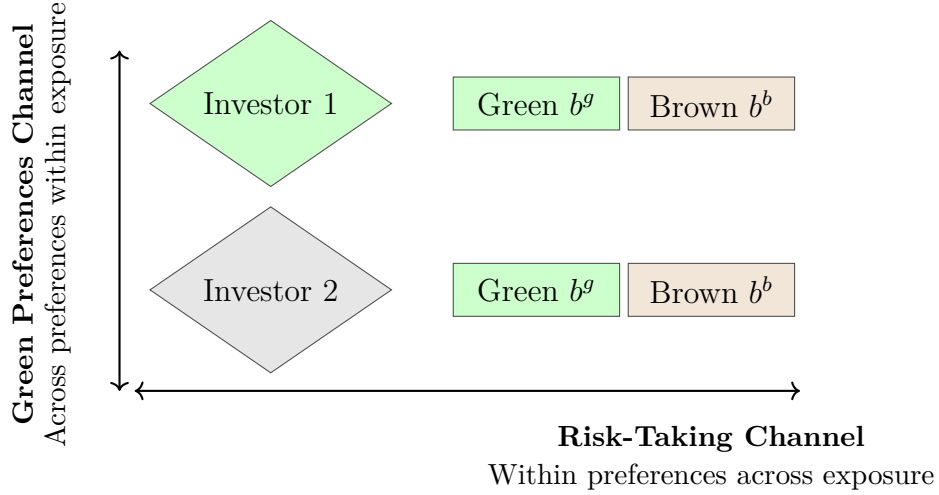
3.5 Identifying the Mechanisms

In this section, I provide evidence of both the risk-taking and the preference channels playing a role in driving my findings. I first focus on results capitalising on a granular investor-firm dataset on US global funds' holdings of foreign securities. I then provide further insights looking at the universe of the syndicated loan market for non-US borrowers.

3.5.1 Identification Strategy

The empirical challenge of disentangling the effect of climate preferences from the risk-taking channel requires the use of data sources combining both investors and companies information. Intuitively and as represented in a stylised way by Figure 3.8, looking at how investors with the *same preferences* allocate capital to companies with different emission profiles is key to pin down the influence

Figure 3.8: Empirical Strategy



of the risk-taking channel, which relies on investors differential carbon exposure across firms, while controlling for the green bias in investing, which varies only across investors with different preferences. Considering how investors with non-sustainable preferences behave with respect to sustainable ones when it comes to their capital allocation for the *same firm*, effectively controls for the contribution of the risk-taking channel, and allows me to shed light on the role of preferences.

In practice, I proceed with considering the universe of US global mutual funds and their quarterly holdings of foreign securities. I first focus on funds with ESG mandates to control for the effects of green preferences. I then run within-fund local projections exploiting the variation in emissions intensity across equity holdings. I find that US global sustainable mutual funds exhibit a higher outflow for browner than greener foreign firms after Fed hikes. This result is consistent with a climate risk-taking channel of monetary policy operating independently from green preferences of investors. Expanding the same dataset to include also other holders of the same securities, which do not have an explicit ESG mandate, allows me to test for a concomitant preference channel. I indeed find that, looking within security holdings and controlling for both fund and company-specific shocks over time through fixed effects, US global ESG mutual funds pull more capital

from browner than greener foreign firms *compared* to non-ESG funds following a US tightening shock.

3.5.2 Empirical Specification

To test for the climate risk-taking channel of US spillovers, I run the following local projection regressions:

$$\frac{y_{i,f,\tau+h} - y_{i,f,\tau-1}}{y_{i,f,\tau-1}} = \beta^h \cdot \varepsilon_\tau^M \times b_{f,t-1} + \eta_h X_{i,f,\tau} + \alpha^h + \delta_f^h + \delta_{c,s,\tau}^h + \delta_{i,\tau}^h + u_{i,f,\tau+h} \quad (3.5.2.1)$$

where the dependent variable is the cumulative change in fund investor i 's number of shares y of firm f 's equity at quarter τ until horizon h from quarter $\tau - 1$, which allows me to consider inflows and outflows controlling for valuation effects.⁴¹ Crucially and in line with my identification strategy, I keep only ESG funds identified through text analysis (van der Beck, 2023). Given I am studying financial actors such as mutual funds, I shorten the horizon to cover just one year, i.e. four quarters, as is common in the related literature (Banegas et al., 2022; Faia et al., 2025).

The object of interest is once again the coefficients β^h on the interaction between firm-level carbon intensity and the measure of monetary policy shock ε_τ^M . This term captures the magnitude and sign of the heterogeneous response of brown compared to green holdings *within funds*. Indeed, I include fund-time fixed effects $\delta_{i,\tau}$ to control for all shocks to and features of investors, as well as a constant α , δ_f firm fixed effects and $\delta_{c,s,\tau}$ country-sector-time fixed effects. Controls X are the same as the ones from 3.3.4.1, and include also holding-specific ones such as lagged values of returns and their four-quarter rolling volatility, security rank, market value and percentage of total net assets. Finally, standard error clustered at firm and quarter level.

I can extend my set-up above by expanding my sample to cover also non-ESG funds which, as part of their wider portfolio, hold the same securities as the sample

⁴¹Focusing on quarterly changes does not constitute a substantial limitation with respect to considering intra-quarter movements. Previous studies using the Ancerno data find that round-trip trades account for less than 20% of a typical mutual fund's intra-quarter trading (Puckett and Yan, 2011).

of ESG funds. In so doing, I am able to test also for the green preference channel of US spillovers by estimating the following local projection regressions:

$$\frac{y_{i,f,\tau+h} - y_{i,f,\tau-1}}{y_{i,f,\tau-1}} = \gamma^h \cdot b_{f,t-1} \times ESG_i + \beta^h \cdot \varepsilon_\tau^M \times b_{f,t-1} \times ESG_i + \alpha^h + \delta_{f,\tau}^h + \delta_{i,\tau}^h + u_{i,f,\tau+h} \quad (3.5.2.2)$$

where the dependent variable is again the cumulative change in fund investor i 's number of shares y of firm f 's equity at quarter τ until horizon h from quarter $\tau - 1$. This time, I keep both ESG and non-ESG funds, as my object of interest is the coefficients β^h on the triple interaction between firm-level carbon intensity, the measure of monetary policy shock ε_τ^M and the ESG_i dummy for a fund with an ESG mandate. This term captures the magnitude and sign of the heterogeneous response of brown relative to green holdings for ESG compared to non-ESG funds. Since the variation I am using for identification is now *across funds* and *within securities*, I can augment the sets of fixed effects by adding next to fund-time fixed effects $\delta_{i,\tau}$, also $\delta_{f,\tau}$ firm-time fixed effects to control for all shocks to and features of the companies in investors' portfolios. I maintain a constant α .⁴² Finally, standard error are clustered at fund, firm and quarter level.

3.5.3 Results

Panel (a) of Figure 3.9 shows results for the estimates β coefficients from (3.5.2.1). The main takeaway is that US global funds appear to divest by more from firms with higher carbon intensity following US monetary policy shocks. Notice how the coefficients are jointly significant, thus we can reject the null that the multiplier is zero. This results suggest that, even when controlling for preferences, a risk-taking channel might be at play. Notice also that this effect adds to the average decrease I find in Figure C.54, in line with results of US tightening shocks driving outflows for US mutual funds found in the literature (Banegas et al., 2022).

On the other hand, Panel (b) of Figure 3.9 reports results for the estimates β coefficients from (3.5.2.2). Here the main takeaway is that ESG funds divest by more than non-ESG funds from firms with higher carbon intensity following US

⁴²I keep also holding-specific controls, including security rank and percentage of total net assets.

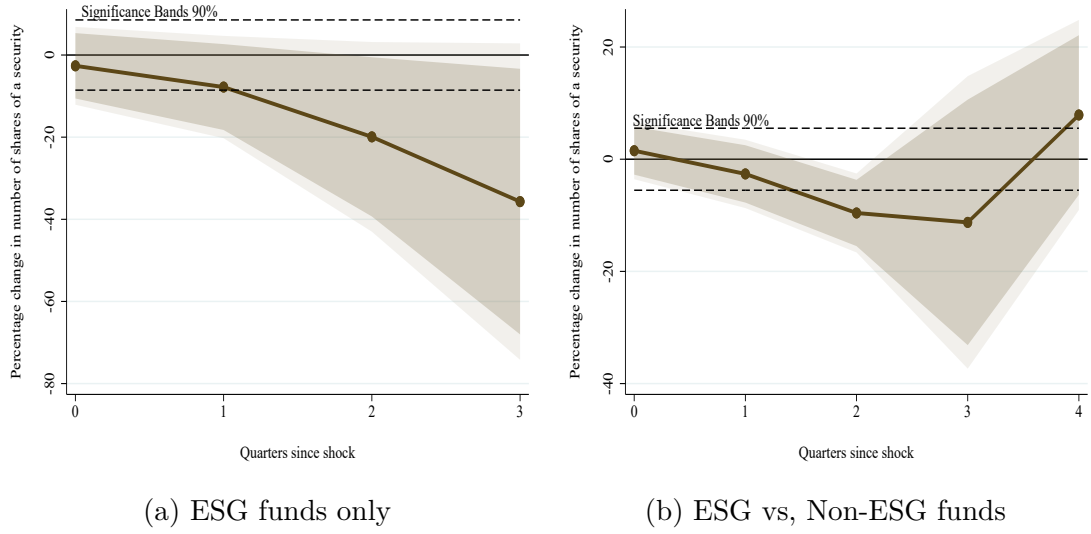


Figure 3.9: Response of non-US holdings to US monetary policy: Scope 1 emission

Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.5.2.1) and (3.5.2.2) for Panel (a) and (b), respectively. Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level (a) and fund, firm and quarter level (b). Significance bands for joint test are constructed using the Wild-Block Bootstrap (Inoue et al., 2025).

monetary policy shocks. Again, the multiplier is significantly different from zero as the coefficients at the different horizons are jointly significant. This means that green preferences have an impact over and above the risk-taking channel.

Comparing the estimates of the two channels, my results suggest that the risk-taking channel might have a larger and more persistent effect compared to the green preferences channel. This means that, as far as ESG funds are concerned, given my identification strategy, the preference channel might be playing a smaller role. Of course, for a comprehensive quantitative assessment, I would need to incorporate these documented channels into a fully fledged structural model able to account for general equilibrium effects which may offset or amplify these empirical results (Benjamin Moll and Oliver Hanney, 2025). I leave this to future research.

3.5.4 Robustness

I include below several robustness checks on the importance of the risk-taking and green preference channels.

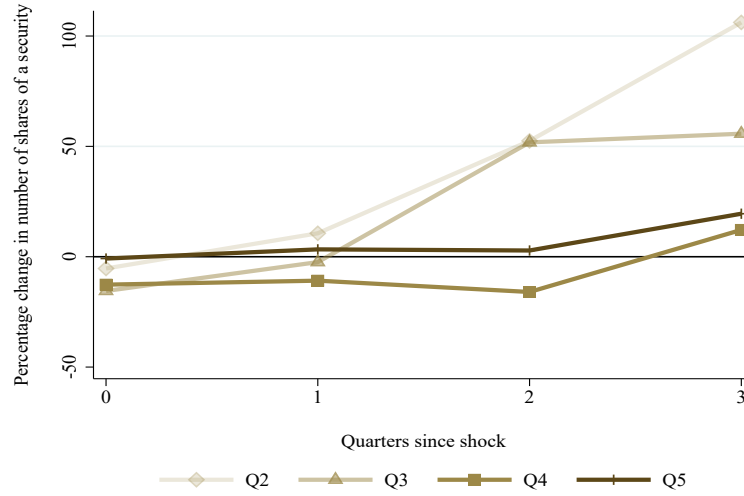


Figure 3.10: Response of non-US holdings of ESG funds to US monetary policy: Scope 1 emission

Notes: Dynamics of the interaction coefficient between brown dummy based on emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.5.2.1), where the emission measure is a dummy for the quintile of the emission intensity distribution. The base group left out is the first quintile.

Quintiles The linear estimates reported by Panel (a) of Figure 3.9 disguise important variation across the distribution of carbon intensity, as showed by Figure 3.10. I run the same regression as in (3.5.2.1) by unpacking the emission variable by quintiles. I drop the first quintile to use it as my benchmark, given I am focusing on ESG funds, and estimate the responses of the different quintiles. I find that, after an exogenous tightening by the Fed, mutual funds decrease their shares of firms from the top 2 brown quintiles, as expected given their lower risk-bearing capacity for those assets. Furthermore, there seems to be a concomitant reallocation towards relatively greener assets, again in line with what would be expected through the risk-bearing channel of monetary spillovers.

Monthly Flows Holdings data are available only at a quarterly frequency, however *overall* flows in and out of mutual funds can be tracked at monthly frequency in CRSP. In Appendix C.2.6 I thus use this information to run a robustness test on my results for the preference channel. Specifically, I study outflows of funds focused

on non-US investment following a US monetary tightening shock, and compare them across ESG and non-ESG funds. Results from this analysis indicate that ESG-mandate funds attenuate their outflows following a US monetary shock, in line with the attenuation mechanism in my model stemming from preferences for green holdings.⁴³ Furthermore, these estimates are statistically significant when considering all equity funds, where retail funds seem to be driving the results. Finally, the reaction to monetary policy is not significantly different from the average for bonds investors — although the sample reduces substantially for those.

Syndicated Lending The salience of the preference channel extends to debt markets, as detailed in Appendix C.2.7. For this analysis, I combine insights from the literature linking dynamics in the syndicated loan markets to climate considerations (G. Hale et al., 2024; Ehlers et al., 2022; Beyene et al., 2021; Benincasa, 2021; Alves et al., 2024) and the transmission of monetary policy (Elliott, Meisenzahl, Peydró and Turner, 2022; Elliott, Meisenzahl and Peydró, 2024; Lee, 2025). I capitalise on the universe of syndicated lending to non-US borrowers, and identify lenders that have made pledges to greening their portfolios (Bolton and M. Kacperczyk, 2025), and in particular banks which are signatories of the SBTi (M. T. Kacperczyk and Peydró, 2022), PRI, TCFD and PRB (G. Hale et al., 2024).

Table C.6 shows the results for this additional exercise. Including tight fixed effects to control for lender and borrower-level factors in my estimation, I find stronger (weaker) divestment from brown (green) companies by lenders with green commitments in response to US monetary tightening — further evidence of the presence of the preference channel. Unpacking this effect, I find this to be driven by the extensive rather than intensive margin. This is further evidence that the green preference channel is at play: while the risk-taking channel acts through increases in cost of borrowing and reductions in lending, a complete divestment, as suggested by the prevalence of the extensive margin, is more consistent with

⁴³Patozi (2023) finds similar results in a closed-economy setting.

sustainable strategies linked to non-pecuniary green preferences in portfolio allocation. Furthermore, I find that loan tenor to brown borrowers does not shorten after the shock. Because risk-management considerations would normally prompt a maturity reduction, the absence of such an effect reinforces the interpretation that lender exit reflects non-pecuniary screening.

3.6 Conclusion

This paper studies how US monetary policy shocks affect foreign firms differentially depending on their carbon emissions. Combining high-frequency monetary surprises with firm-level data for about 5,000 non-U.S. firms across 38 countries, I show that US monetary tightening disproportionately impacts higher, “brown”, relative to lower, “green”, emitters: investment, debt, and equity prices decline more sharply, while bond spreads rise more for firms with higher carbon intensity. To rationalise these findings, I develop a model featuring global sustainable investors with limited risk-bearing capacity for transition-risky assets and preferences for holding green securities. Each channel implies that tighter US monetary policy widens the return differential between brown and green assets, amplifying capital reallocation away from brown firms. I overcome this identification challenge by matching granular investor-firm data which allow me to estimate US spillovers *within* investors’ preferences and *across* firms’ carbon intensity, and vice versa. Through this strategy, I find empirical support for risk and preference channels, respectively. My findings suggest that emission-dependent monetary spillovers can make greener countries more resilient to global financial tightening, while browner ones, e.g. emerging economies, are penalised.

Going forward, there are several avenues for future investigations. First, a natural question to ask is what are the aggregate consequences of the heterogeneous responses I documented, and their underpinning channels. To translate my insights into quantifiable aggregate spillovers to non-US and spillbacks, as already mentioned, one would need a fully fledged structural model (Benjamin Moll and Oliver Hanney, 2025). In follow-up work I am thus developing a novel

two-country model featuring two distinct sectors – green and brown – alongside international intermediaries, and exhibiting the two forms of financial frictions underpinning the identified mechanisms above. With such a model it is thus possible to run quantitative simulation exercises to assess the economic importance of each channel, as well as the sensitivity of spillovers to non-US economies and spillbacks to US and how they depend on relative “brownness” across economies. This quantification would be of first-order importance for policymakers, as my empirical evidence highlighted both the climate risk-taking and the preference channels might represent sources of resilience to US monetary tightening for greener economies, while a mechanism of penalisation for browner ones, such as emerging market economies — precisely the ones that need more support to catch up and accelerate their climate transition.

Second, my stylised framework makes several simplifications which could be relaxed in future work. On the one hand, for example, in my model cash-flows are discounted at the risk-free rate, while in reality the discount rate for green and brown securities may differ, and may also respond differently to monetary policy shocks (Döttling and Lam, 2023). On the other hand, preferences for green assets could be affected by monetary policy, for example if they are considered a luxury good (Bansal et al., 2022; Andersen et al., 2023). However, in this case, contractionary monetary policy might drive investors to put aside non-pecuniary motives such as green preferences, attenuating rather than amplifying adverse effects of monetary spillovers — thus not consistent with my empirical evidence. More evidence on this potential reversal effect would be particularly valuable as monetary policy and financial conditions have become more restrictive globally over the past years.

Finally, my paper highlights the important driver of investors’ decisions, and thus asset prices, represented by building hedging portfolios against climate risk. Indeed, climate risk is distinctive because many of the impacts of climate change will unfold further in the future, meaning that neither financial derivatives nor

specialized insurance markets currently exist to directly hedge against these long-term risks (Giglio et al., 2021). However, financial innovation and derivatives markets can play a major role in helping countries achieve their goal of a low-carbon economy, and many new initiatives are afoot such as disaster derivatives, ESG-linked swaps, and carbon emission futures (Saguato, 2023). With innovation come, as always, benefits but also concerns in terms of financial stability and potential changes to the transmission of policy — all interesting avenues of further research.

Appendices

A

Appendix to Chapter 1

Contents

A.1	Additional Stylised Facts on Aggregate Capital Flows and the 2014 Sectoral Sanctions Against Russia	163
A.2	Appendix to the Firm-Level Empirical Analysis	166
A.3	Appendix to the UK Resident Bank-level Empirical Analysis	173
A.4	Appendix to the Syndicated Loan Empirical Analysis	190
	A.4.1 Stylised Facts	190
	A.4.2 Additional Empirical Evidence	190
A.5	Appendix to the Capital Flows View of Geo-economic Power	194

A.1 Additional Stylised Facts on Aggregate Capital Flows and the 2014 Sectoral Sanctions Against Russia

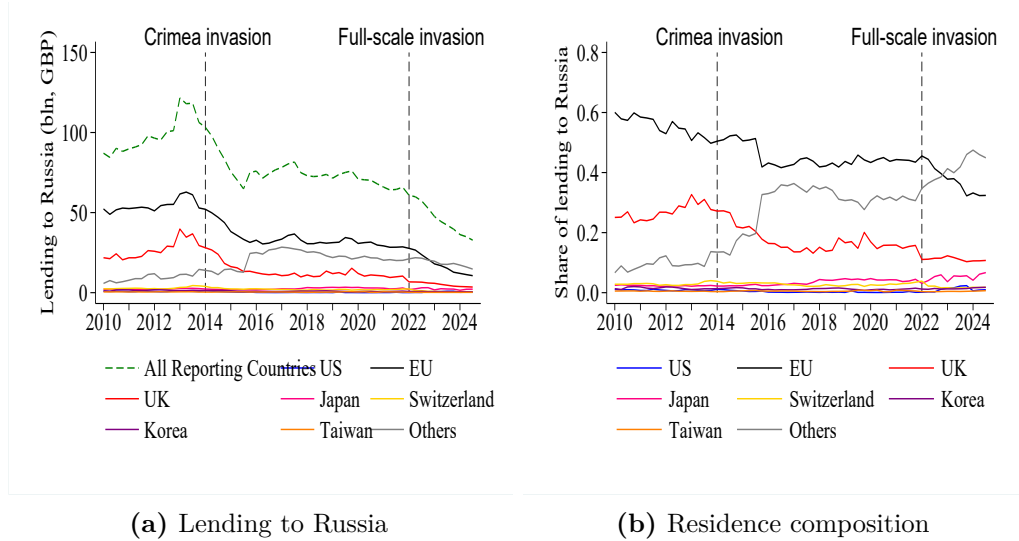


Figure A.1: Global Cross-Border Claims to Russia by Residence.

Note. – Amount outstanding of total cross-border claims including all counterparty sectors, all currency types of reporting country, all types of instruments, all parent countries and all reporting institutions. Lending converted from USD into GBP using quarterly averages of spot FX reported by the Bank of England. Proportion of each currency group out of total lending to Russia is in simple shares from 0 to 1.

Source: BIS locational banking dataset.

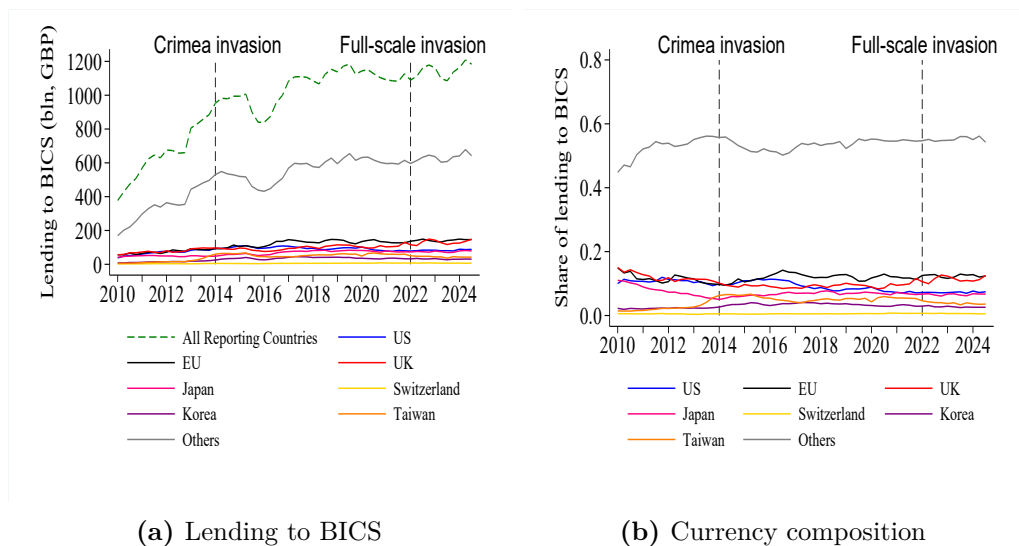


Figure A.2: Global Cross-Border Claims to BICS by Residence.

Note. – Amount outstanding of total cross-border claims including all counterparty sectors, all currency types of reporting country, all types of instruments, all parent countries and all reporting institutions. Lending converted from USD into GBP using quarterly averages of spot FX reported by the Bank of England. Proportion of each currency group out of total lending to Russia is in simple shares from 0 to 1.

Source: BIS locational banking dataset.

Table A.1: EU-U.S. 2014 Sectoral Sanctions Lists

	United States	European Union
Energy		
Rosneft	✓	✓
Transneft	✓	✓
Gazprom Neft	✓	✓
Novatek	✓	×
Financial Services		
Sberbank	✓	✓
VTB	✓	✓
Gazprom Bank	✓	✓
Rosselkhozbank	✓	✓
Vnesheconombank	✓	✓
Defense		
Rostec	✓	×
UAC (Rostec Group)	—	✓
Oboronprom (Rostec Group)	—	✓
Uralvagonzavod (Rostec Group)	—	✓

The table reports the list of operating companies designated by the U.S. and EU sectoral sanctions lists in 2014, as well as subsidiaries when the operating parent is not designated itself (i.e. Gazprom Neft and, for the EU only, three Rostec's subsidiaries). Source: OFAC and European Commission.

A.2 Appendix to the Firm-Level Empirical Analysis

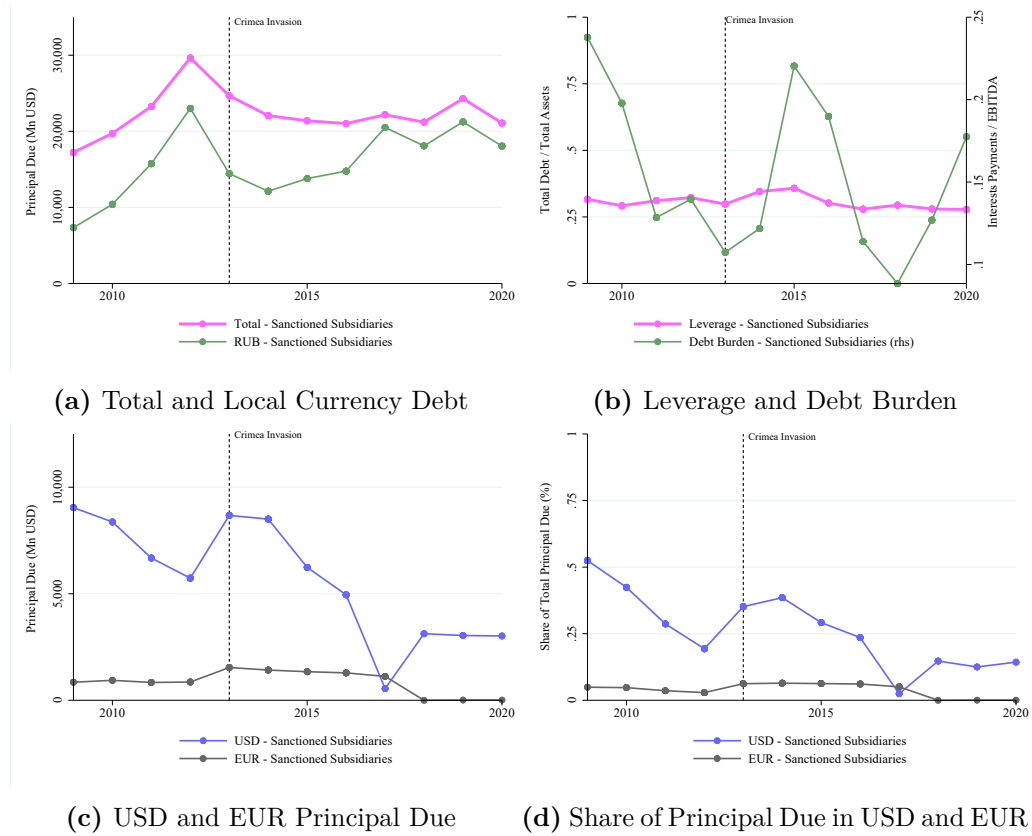


Figure A.3: Debt Profile of Russian non-Operating Companies under Sectoral Sanctions.

Note. – The figure aggregates data for the non-operating companies under sectoral sanctions in our dataset, namely Gazprom Neft and several subsidiaries of defense conglomerate Rostec.

Source: Capital IQ, Authors' calculations.

Table A.2: Currency Debt Levels

	USD Debt			EUR Debt			Dom. Debt			Debt by Currency		
	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD
Post × Russia	−0.933*** (0.279)	−0.368 (0.238)	−0.603** (0.238)	0.231 (0.250)	0.918*** (0.256)	0.741** (0.363)	−0.608*** (0.114)	−0.148** (0.073)	−0.363** (0.176)			
Post × Russia × Sanctioned			−0.194 (0.191)			−0.528*** (0.178)			−0.238* (0.144)			
Post × Russia × EUR										1.140*** (0.357)	0.980*** (0.197)	0.976*** (0.198)
Post × Russia × Sanctioned × EUR												0.193 (0.327)
Post × Russia × Domestic										0.820*** (0.244)	0.816*** (0.194)	0.808*** (0.196)
Post × Russia × Sanctioned × Domestic												0.020 (0.220)
Estimator	PPML	PPML	PPML	PPML	PPML	PPML	PPML	PPML	PPML	PPML	PPML	PPML
Sanct. total			−0.797***			0.212			−0.601***			
SE: Sanct. total			(0.193)			(0.257)			(0.111)			
Sanct. total EUR												1.169
SE: Sanct. total EUR												(0.360)
Sanct. total Dom.												0.827
SE: Sanct. total Dom.												(0.242)
Fixed effects	Firm, sector-time			Firm, sector-time			Firm, sector-time			Firm-year, firm-curr., curr.-year		
Observations	937	1,049	1,128	373	440	509	863	964	1,043	3,066	3,304	3,557
Pseudo R-squared	0.843	0.849	0.850	0.786	0.937	0.918	0.991	0.993	0.991	0.990	0.991	0.990

Estimating sample includes firms in Russia, BRICS+ and CEEMEA emerging markets with more than 1bn USD denominated debt in 2013. Currency-specific columns are estimated at the firm-year level and cluster standard errors by country. The debt-by-currency column is estimated at the firm-year-currency level with USD as the omitted currency bucket and clusters standard errors by firm. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.3: Firm-Level Debt and Leverage (All Firms)

	Total Debt			Leverage		
	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD
Post $\times$ Russia	-0.414*** (0.070)	-0.414*** (0.114)	-0.414*** (0.113)	-0.068*** (0.009)	0.041 (0.027)	0.040 (0.027)
Post $\times$ Russia $\times$ Sanctioned			0.012 (0.076)			-0.106*** (0.025)
Estimator	OLS	OLS	OLS	OLS	OLS	OLS
Observations	9,831	9,946	10,023	9,835	9,950	10,027
R-squared	0.912	0.910	0.911	0.871	0.870	0.870

Estimating sample includes all firms with more than 1bn USD denominated debt in 2013. Firm and sector-time fixed effects are included in all specifications. Standard errors are clustered by country. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.4: Interest Expenses and Debt Burden (All Firms)

	Interest Expenses			Debt Burden		
	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD
Post $\times$ Russia	0.598*** (0.154)	-0.426** (0.164)	-0.433** (0.163)	0.336*** (0.124)	-0.397*** (0.147)	-0.404*** (0.147)
Post $\times$ Russia $\times$ Sanctioned			1.046*** (0.078)			0.756*** (0.100)
Estimator	OLS	OLS	OLS	OLS	OLS	OLS
Observations	8,219	8,370	8,392	7,958	8,109	8,131
R-squared	0.858	0.858	0.858	0.788	0.788	0.789

Estimating sample includes all firms with more than 1bn USD denominated debt in 2013. Firm and sector-time fixed effects are included in all specifications. Standard errors are clustered by country. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.5: Currency Debt Levels (All Firms / Broad Sample)

	USD Debt			EUR Debt			Dom. Debt			Debt/Curr. Excl. US/EA			Debt/Curr. Incl. US/EA		
	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD
Post × Russia	−0.651*** (0.059)	−0.640*** (0.085)	−0.644*** (0.082)	0.536 (0.360)	0.487 (0.524)	0.500 (0.515)	−0.184 (0.251)	−0.068 (0.070)	−0.101 (0.091)						
Post × Russia × Sanctioned			−0.000 (0.105)			0.028 (0.198)			−0.087 (0.208)						
Post × Russia × EUR										1.076*** (0.354)	0.951*** (0.184)	1.055*** (0.191)	0.808** (0.350)	0.660*** (0.179)	0.768*** (0.187)
Post × Russia × Sanctioned × EUR												0.113 (0.330)			0.136 (0.330)
Post × Russia × Domestic										0.874*** (0.260)	0.859*** (0.214)	1.071*** (0.297)	1.012*** (0.271)	1.006*** (0.256)	1.058*** (0.237)
Post × Russia × Sanctioned × Domestic												−0.026 (0.223)			−0.013 (0.215)
Sample	Excl. US/EA			Excl. US/EA			Excl. US/EA			Excl. US/EA			Incl. US/EA		
Estimator	PPML	PPML	PPML	PPML	PPML	PPML	PPML	PPML	PPML	PPML	PPML	PPML	PPML	PPML	PPML
Sanct. total			−0.644***			0.528			−0.188						
SE: Sanct. total			(0.054)			(0.354)			(0.246)						
Sanct. total EUR												1.167			0.904
SE: Sanct. total EUR												(0.352)			(0.351)
Sanct. total Dom.												1.045			1.045
SE: Sanct. total Dom.												(0.293)			(0.253)
Fixed effects	Firm, sector-time			Firm, sector-time			Firm, sector-time			Firm-year, firm-curr., curr.-year			Firm-year, firm-curr., curr.-year		
Observations	3,228	3,321	3,398	1,407	1,450	1,538	2,424	2,506	2,583	5,224	5,462	8,657	9,488	9,726	12,921
Pseudo R-squared	0.944	0.945	0.943	0.860	0.881	0.877	0.977	0.978	0.977	0.990	0.991	0.980	0.991	0.992	0.987

Estimating sample includes all firms with more than 1bn USD denominated debt in 2013, excluding US and euro-area firms in the currency-specific columns and excluding listed multilateral or supranational borrowers. Currency-specific columns are estimated at the firm-year level and cluster standard errors by country. Debt-by-currency columns are estimated at the firm-year-currency level and cluster standard errors by firm; the inclusive version keeps US and euro-area firms but classifies US USD and euro-area EUR as domestic. Sanct. total for currency-specific columns reports the sum of coefficients and corresponding lincom standard errors. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.6: Currency Debt Shares

	USD Share			EUR Share			Dom. Share			Share by Currency		
	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD
Post $\times$ Russia	-0.041 (0.033)	-0.046 (0.060)	-0.042 (0.057)	0.033*** (0.009)	0.043*** (0.009)	0.040*** (0.009)	0.004 (0.038)	-0.029 (0.047)	-0.029 (0.046)			
Post $\times$ Russia $\times$ Sanctioned			0.001 (0.039)			-0.001 (0.008)			0.029 (0.034)			
Post $\times$ Russia $\times$ EUR										0.083** (0.035)	0.061 (0.063)	0.062 (0.063)
Post $\times$ Russia $\times$ Sanctioned $\times$ EUR												0.021 (0.067)
Post $\times$ Russia $\times$ Domestic										0.088 (0.086)	0.082 (0.096)	0.083 (0.096)
Post $\times$ Russia $\times$ Sanctioned $\times$ Domestic												0.005 (0.119)
Estimator	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Sanct. total			-0.041			0.039***				0.000		
SE: Sanct. total			(0.039)			(0.008)				(0.036)		
Sanct. total EUR												0.083**
SE: Sanct. total EUR												(0.035)
Sanct. total Dom.												0.088
SE: Sanct. total Dom.												(0.086)
Fixed effects	Firm, sector-time			Firm, sector-time			Firm, sector-time			Firm-year, firm-curr., curr.-year		
Observations	937	1,049	1,128	937	1,049	1,128	937	1,049	1,128	3,771	4,050	4,314
R-squared	0.852	0.845	0.847	0.759	0.774	0.763	0.817	0.823	0.821	0.865	0.866	0.865

Estimating sample includes firms in Russia, BRICS+ and CEEMEA emerging markets with more than 1bn USD denominated debt in 2013. Currency-specific columns are estimated at the firm-year level and cluster standard errors by country. The share-by-currency column is estimated at the firm-year-currency level with USD as the omitted currency bucket and clusters standard errors by firm. Sanct. total EUR and Dom. report lincom sums of coefficients and corresponding standard errors. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.7: Currency Debt Shares (All Firms / Broad Sample)

	USD Share			EUR Share			Dom. Share			Share/Curr. Excl. US/EA			Share/Curr. Incl. US/EA		
	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD	Sanct.	Non-Sanct.	DiD
Post $\times$ Russia	-0.092 (0.058)	-0.090** (0.036)	-0.084** (0.033)	0.040*** (0.007)	0.039*** (0.010)	0.037*** (0.010)	0.058 (0.051)	0.035 (0.029)	0.033 (0.027)						
Post $\times$ Russia $\times$ Sanctioned			-0.010 (0.039)			0.006 (0.007)									
Post $\times$ Russia $\times$ EUR										0.096*** (0.032)	0.074 (0.061)	0.074 (0.061)	0.090*** (0.030)	0.069 (0.060)	0.069 (0.060)
Post $\times$ Russia $\times$ Sanctioned $\times$ EUR												0.022 (0.067)			0.021 (0.067)
Post $\times$ Russia $\times$ Domestic										0.131 (0.080)	0.126 (0.091)	0.126 (0.091)	0.141* (0.079)	0.135 (0.090)	0.135 (0.090)
Post $\times$ Russia $\times$ Sanctioned $\times$ Domestic												0.006 (0.119)			0.006 (0.119)
Sample	Excl. US/EA			Excl. US/EA			Excl. US/EA			Excl. US/EA			Incl. US/EA		
Estimator	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Sanct. total			-0.094* (0.048)			0.043*** (0.007)			0.058 (0.043)						
SE: Sanct. total															
Sanct. total EUR												0.096*** (0.032)			0.090*** (0.030)
SE: Sanct. total EUR															
Sanct. total Dom.												0.132 (0.080)			0.141* (0.079)
SE: Sanct. total Dom.															
Fixed effects	Firm, sector-time			Firm, sector-time			Firm, sector-time			Firm-year, firm-curr., curr.-year			Firm-year, firm-curr., curr.-year		
Observations	3,238	3,331	3,408	3,238	3,331	3,408	3,238	3,331	3,408	11,562	11,841	12,105	32,493	32,772	33,036
R-squared	0.878	0.874	0.874	0.850	0.850	0.846	0.887	0.885	0.884	0.904	0.904	0.902	0.964	0.964	0.963

Estimating sample includes all firms with more than 1bn USD denominated debt in 2013, excluding US and euro-area firms in the currency-specific columns and excluding listed multilateral or supranational borrowers. Currency-specific columns are estimated at the firm-year level and cluster standard errors by country. Share-by-currency columns are estimated at the firm-year-currency level with USD as the omitted currency bucket and cluster standard errors by firm; the inclusive version keeps US and euro-area firms but classifies US USD and euro-area EUR as domestic. Sanct. total rows report the lincom sum of coefficients and corresponding standard errors. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

A.3 Appendix to the UK Resident Bank-level Empirical Analysis

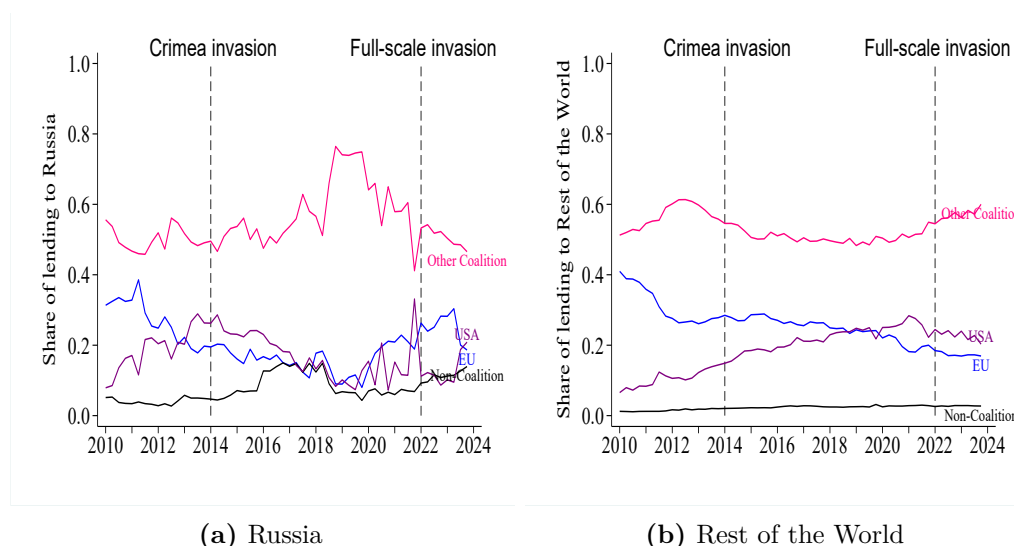


Figure A.4: Coalition composition of lending to non-residents.

Note. – Proportion of each country group out of total lending to Russia and Rest of the World is in simple shares from 0 to 1. “Other Coalition” includes AUS, CAN, CHE, GBR, ISL, JPN, NOR; “Non-Coalition” includes ARE, BHR, BRA, CHN, EGY, GHA, KOR, HKG, IDN, IND, IRN, ISR, JOR, KWT, LBY, MAR, MEX, MYS, NGA, QAT, RUS, SAU, SGP, THA, TUR, TWN, ZAF. Rest of the World includes only countries not subject to US financial sanctions as measured by the Global Sanctions Data Base (Felbermayr et al., 2020; Yalcin et al., 2025).

Source: Bank of England’s dataset on claims of UK banks on non-residents.

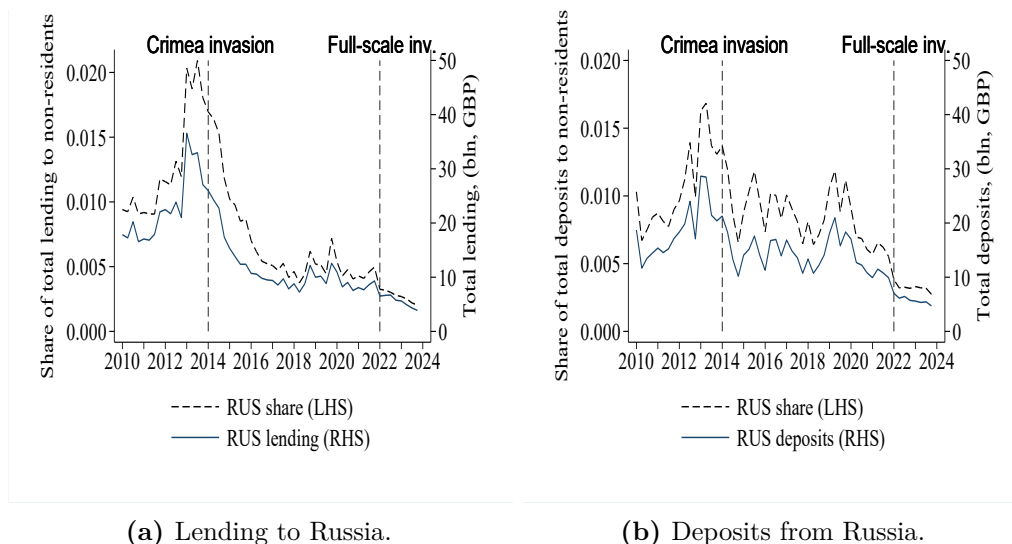


Figure A.5: UK-resident global banks' total lending to and deposits from Russia.

Note. – Lending and deposits are in GBP Billions. Proportion of Russia lending out of total non-resident lending is in simple shares from 0 to 1.

Source: Bank of England's dataset on claims and liabilities of UK banks on non-residents.

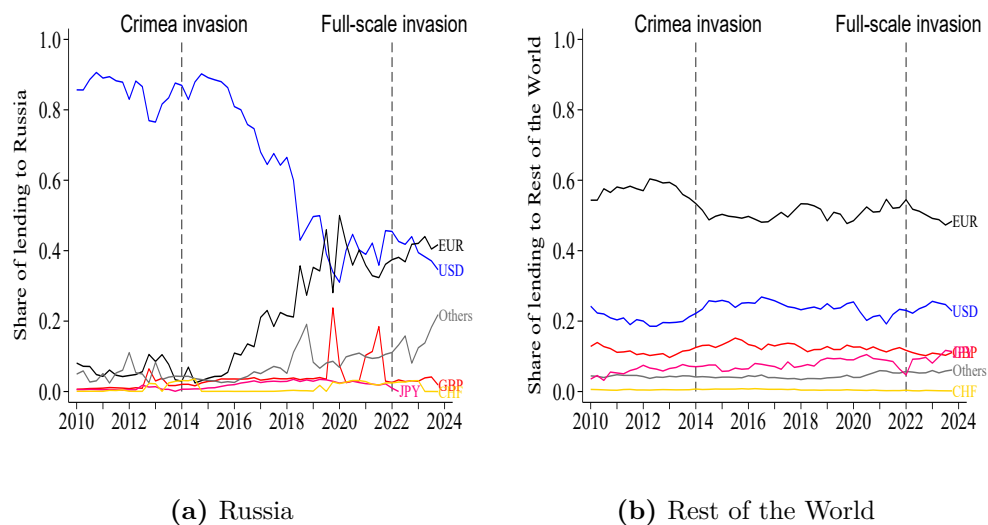
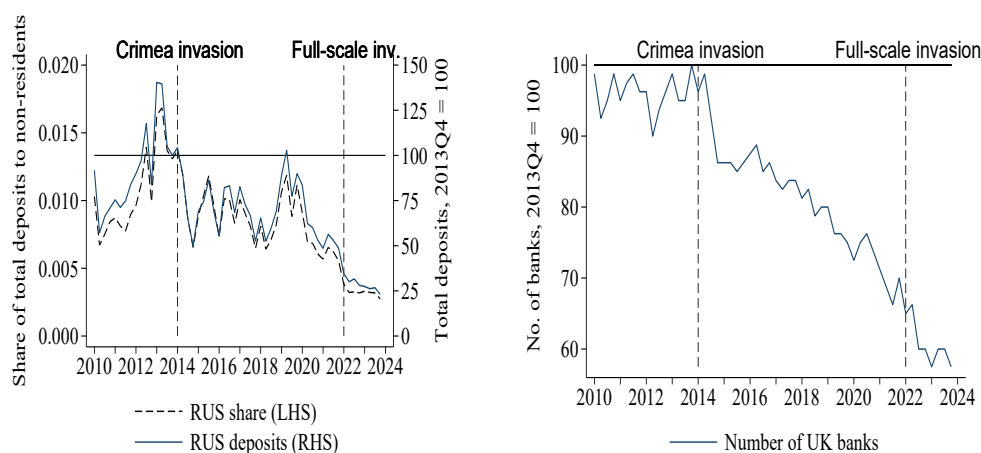


Figure A.6: Currency composition of lending to non-residents. Lending growth winsorised to be $[-100\%, 100\%]$.

Note. – Proportion of each currency group out of total lending to Russia and Rest of the World is in simple shares from 0 to 1. Rest of the World includes only countries not subject to US financial sanctions as measured by the Global Sanctions Data Base (Felbermayr et al., 2020; Yalcin et al., 2025).

Source: Bank of England's dataset on claims of UK banks on non-residents.



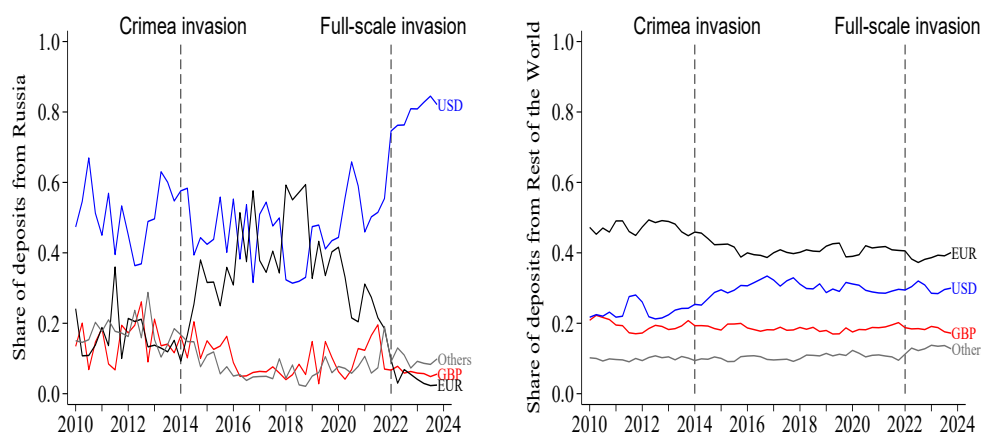
(a) Deposits from Russia.

(b) Banks taking deposits from Russia.

Figure A.7: UK-resident global banks' total deposits from Russia.

Note. – Lending and number of banks are indexed to be 100 in the fourth quarter of 2013, that is the quarter before Russia's invasion of Crimea. Proportion of Russia lending out of total non-resident lending is in simple shares from 0 to 1.

Source: Bank of England's dataset on liabilities of UK banks on non-residents.



(a) Russia

(b) Rest of the World

Figure A.8: Currency composition of deposits from non-residents.

Note. – Proportion of each currency group out of total lending to Russia and Rest of the World is in simple shares from 0 to 1. Rest of the World includes only countries not subject to US financial sanctions as measured by the Global Sanctions Data Base (GSDB) created by Felbermayr et al. (2020).

Source: Bank of England's dataset on liabilities of UK banks on non-residents.

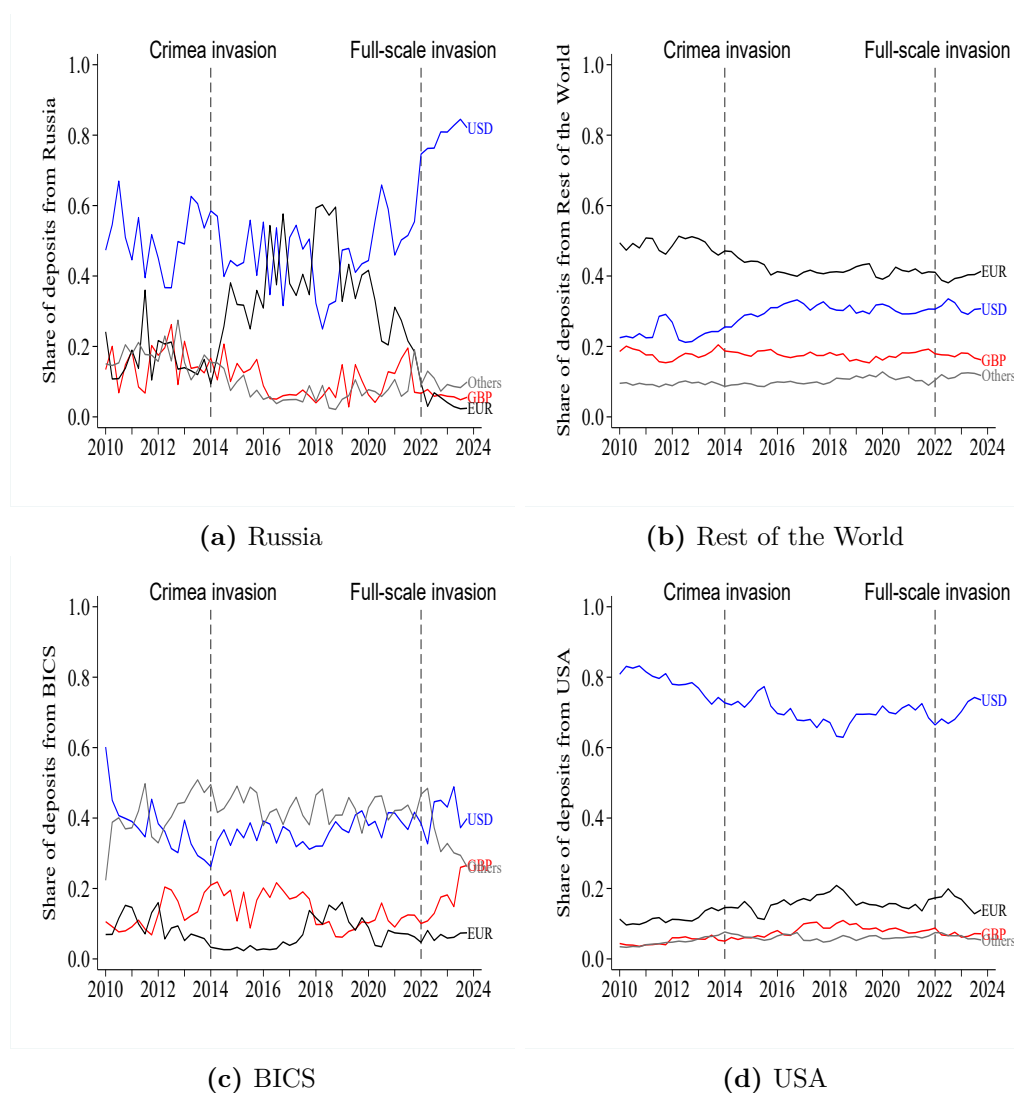


Figure A.9: Currency composition of deposits from non-residents. (Only banks lending to Russia)

Note. – Proportion of each currency group out of total lending is in simple shares from 0 to 1. Sanctioned countries (Rest of the World) includes only countries (not) subject to US financial sanctions as measured by the Global Sanctions Data Base (GSDB) created by Felbermayr et al. (2020).

Source: Bank of England's dataset on liabilities and claims of UK banks on non-residents.

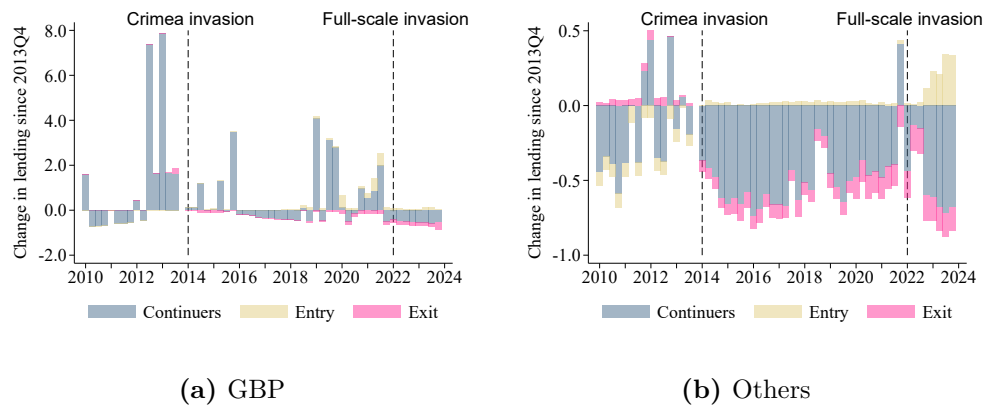


Figure A.10: Margins decomposition: Total lending to Russia in GBP and “Other” Currencies

Note. – Bars within every quarter add up to the total change in lending to Russia for that currency with respect to 2013Q4.

Source: Bank of England’s dataset on claims of UK banks on non-residents.

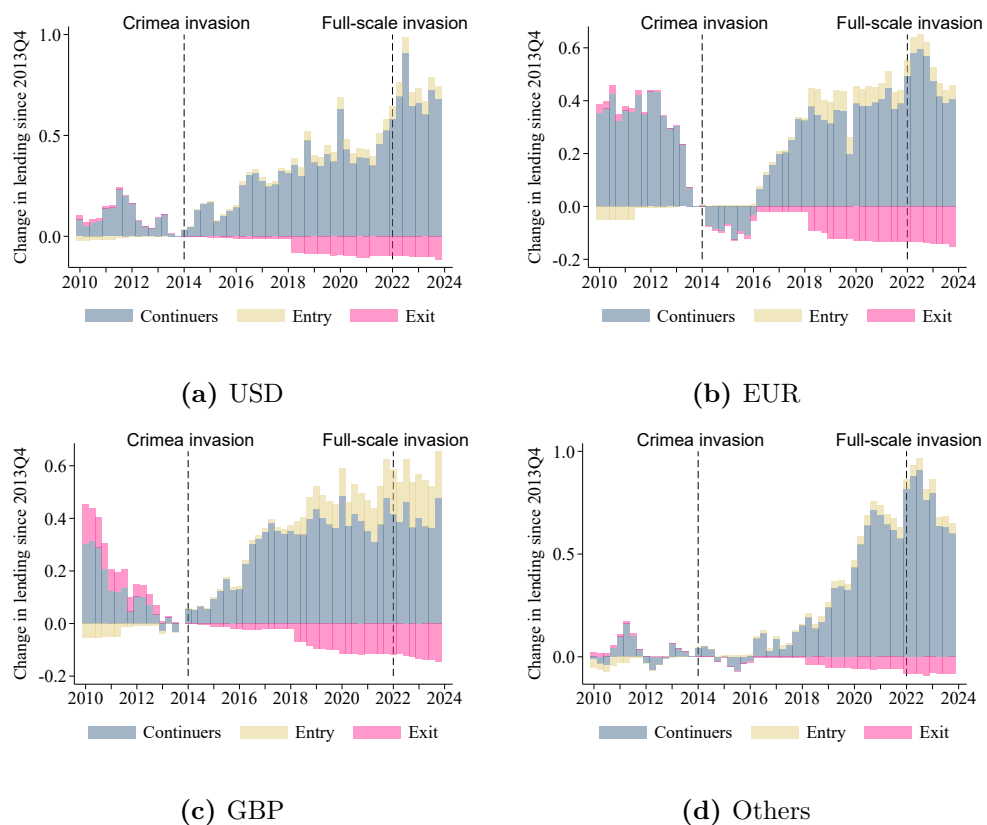


Figure A.11: Margins decomposition: Total lending to all countries other than Russia.

Note. – Bars within every quarter add up to the total change in lending to Russia for that currency with respect to 2013Q4.

Source: Bank of England’s dataset on claims of UK banks on non-residents.

Table A.8: Bank Claims on Russia after the 2014 Sectoral Sanctions: Currency-Margin Fixed-Effect Variants

	Non-USD vs. USD				EUR vs. USD			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Estimated Interaction Terms								
Coalition $\times$ Post (γ_1)	-0.584** (0.289)	-0.585** (0.279)		-0.584** (0.291)	-0.584** (0.290)	-0.585** (0.279)		-0.584** (0.291)
Currency $\times$ Post (γ_2)	1.381** (0.680)	1.380** (0.689)	1.490** (0.666)		2.014*** (0.642)	2.013*** (0.656)	1.895*** (0.610)	
Currency $\times$ Post $\times$ Coalition (γ_3)	-0.505 (0.710)	-0.504 (0.718)	-0.827 (0.700)	-0.505 (0.719)	-0.739 (0.694)	-0.738 (0.706)	-0.887 (0.675)	-0.739 (0.709)
Panel B. Currency Margin: Claims Relative to USD								
<i>Between:</i> Coalition Effect, USD Claims (γ_1)	-0.584** (0.289)	-0.585** (0.279)		-0.584** (0.291)	-0.584** (0.290)	-0.585** (0.279)		-0.584** (0.291)
<i>Within</i> Non-Coalition: Non-USD (EUR) Shift (γ_2)	1.381** (0.680)	1.380** (0.689)	1.490** (0.666)		2.014*** (0.642)	2.013*** (0.656)	1.895*** (0.610)	
<i>Between:</i> Difference in Non-USD (EUR) Shift (γ_3)	-0.505 (0.710)	-0.504 (0.718)	-0.827 (0.700)	-0.505 (0.719)	-0.739 (0.694)	-0.738 (0.706)	-0.887 (0.675)	-0.739 (0.709)
<i>Within</i> Coalition: Non-USD (EUR) Shift ($\gamma_2 + \gamma_3$)	0.876*** (0.277)	0.876*** (0.275)	0.663*** (0.228)	-0.505 (0.719)	1.275*** (0.349)	1.275*** (0.347)	1.008*** (0.299)	-0.739 (0.709)
<i>Between:</i> Coalition Effect, Non-USD (EUR) Claims ($\gamma_1 + \gamma_3$)	-1.089 (0.850)	-1.089 (0.855)	-0.827 (0.700)	-1.089 (0.854)	-1.323 (0.823)	-1.323 (0.831)	-0.887 (0.675)	-1.323 (0.831)
Observations	10,412	10,412	4,832	10,412	7,967	7,967	3,742	7,967
Bank-Currency FE	✓	✓	✓	✓	✓	✓	✓	✓
Quarter FE	✓				✓			
Bank-Quarter FE			✓				✓	
Currency-Quarter FE				✓				✓

Notes. The dependent variable is claims on Russia. Columns (1)–(4) compare claims denominated in all non-USD currencies to claims denominated in USD. Columns (5)–(8) keep only USD and EUR claims and compare EUR-denominated claims to USD-denominated claims. Entries are PPML log coefficients or linear combinations of PPML log coefficients. Standard errors are clustered by bank and quarter. In the row labels, “Within” denotes currency-category shifts relative to USD within the indicated bank group, while “Between” denotes coalition versus non-coalition comparisons. “Non-USD (EUR)” means non-USD in columns (1)–(4) and EUR in columns (5)–(8). USD and non-coalition banks are the omitted categories. All specifications include the fixed effects reported at the bottom of the table. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.9: Bank Claims on Russia after the 2014 Sectoral Sanctions: Split by Currency

	(1) EUR	(2) GBP	(3) OTH
Panel A. Estimated Interaction Terms			
Coalition $\times$ Post (γ_1)	-0.584** (0.289)	-0.584** (0.289)	-0.584** (0.289)
Currency $\times$ Post (γ_2)	2.014*** (0.643)	0.252 (0.473)	-0.827* (0.501)
Currency $\times$ Post $\times$ Coalition (γ_3)	-0.739 (0.696)	0.365 (0.607)	1.186** (0.583)
Panel B. Currency Margin: Claims Relative to USD			
<i>Between:</i> Coalition Effect, USD Claims (γ_1)	-0.584** (0.289)	-0.584** (0.289)	-0.584** (0.289)
<i>Within</i> Non-Coalition: Column-Currency Shift (γ_2)	2.014*** (0.643)	0.252 (0.473)	-0.827* (0.501)
<i>Between:</i> Difference in Column-Currency Shift (γ_3)	-0.739 (0.696)	0.365 (0.607)	1.186** (0.583)
<i>Within</i> Coalition: Column-Currency Shift ($\gamma_2 + \gamma_3$)	1.275*** (0.350)	0.616* (0.362)	0.359 (0.311)
<i>Between:</i> Coalition Effect, Column-Currency Claims ($\gamma_1 + \gamma_3$)	-1.323 (0.825)	-0.219 (0.561)	0.602 (0.554)
Observations	13,865	13,865	13,865
Sample	Russia	Russia	Russia
Currency Definition	USD vs. EUR, GBP, OTH	USD vs. EUR, GBP, OTH	USD vs. EUR, GBP, OTH
Estimator	PPML	PPML	PPML
Bank-Currency FE	✓	✓	✓
Quarter FE	✓	✓	✓

Notes. The dependent variable is claims on Russia. This table reports currency-specific coefficients and linear combinations from the baseline Russia-sample model with USD, EUR, GBP, and OTH. The USD coalition effect, γ_1 , is common across the three column-currency contrasts and is therefore reported once across columns. Entries are PPML log coefficients or linear combinations of PPML log coefficients. Standard errors are clustered by bank and quarter. In the row labels, “Within” denotes shifts in the column currency relative to USD within the indicated bank group, while “Between” denotes coalition versus non-coalition comparisons. USD and non-coalition banks are the omitted categories. CHF and JPY are not included in this split because of sparse support. All specifications include the fixed effects reported at the bottom of the table. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.10: Bank Claims on Russia Relative to Other Destinations after the 2014 Sectoral Sanctions: Currency-Margin Fixed-Effect Variants

	Non-USD vs. USD					EUR vs. USD				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A. Estimated Interaction Terms										
Coalition $\times$ Post $\times$ Russia ($\tilde{\gamma}_1$)	-0.326*** (0.104)	-0.340*** (0.083)	-0.329*** (0.086)	-0.285** (0.119)	-0.340*** (0.073)	-0.222** (0.087)	-0.340*** (0.077)	-0.296*** (0.080)	-0.251** (0.107)	-0.340*** (0.067)
Currency $\times$ Post $\times$ Russia ($\tilde{\gamma}_2$)	1.339*** (0.517)	1.082** (0.460)	1.081** (0.537)	1.237*** (0.475)	1.082** (0.444)	1.790*** (0.566)	1.697*** (0.550)	1.558*** (0.534)	1.716*** (0.567)	1.697*** (0.540)
Currency $\times$ Post $\times$ Coalition ($\tilde{\gamma}_3$)	-0.312 (0.380)	-0.478* (0.274)	-0.339 (0.305)	-0.380 (0.363)	-0.478* (0.274)	-0.382 (0.401)	-0.579 (0.396)	-0.503 (0.401)	-0.463 (0.408)	-0.579 (0.396)
Currency $\times$ Post $\times$ Russia $\times$ Coalition ($\tilde{\gamma}_4$)	-0.491 (0.539)	-0.027 (0.481)	-0.166 (0.565)	-0.339 (0.490)	-0.026 (0.469)	-0.494 (0.593)	-0.159 (0.559)	-0.236 (0.579)	-0.324 (0.587)	-0.159 (0.551)
Panel B. Currency Margin: Claims Relative to USD										
<i>Between:</i> Coalition Effect, USD Claims ($\tilde{\gamma}_1$)	-0.326*** (0.104)	-0.340*** (0.083)	-0.329*** (0.086)	-0.285** (0.119)	-0.340*** (0.073)	-0.222** (0.087)	-0.340*** (0.077)	-0.296*** (0.080)	-0.251** (0.107)	-0.340*** (0.067)
<i>Within</i> Non-Coalition: Non-USD (EUR) Shift ($\tilde{\gamma}_2$)	1.339*** (0.517)	1.082** (0.460)	1.081** (0.537)	1.237*** (0.475)	1.082** (0.444)	1.790*** (0.566)	1.697*** (0.550)	1.558*** (0.534)	1.716*** (0.567)	1.697*** (0.540)
<i>Between:</i> Difference in Non-USD (EUR) Shift ($\tilde{\gamma}_4$)	-0.491 (0.539)	-0.027 (0.481)	-0.166 (0.565)	-0.339 (0.490)	-0.026 (0.469)	-0.494 (0.593)	-0.159 (0.559)	-0.236 (0.579)	-0.324 (0.587)	-0.159 (0.551)
<i>Within</i> Coalition: Non-USD (EUR) Shift ($\tilde{\gamma}_2 + \tilde{\gamma}_4$)	0.847*** (0.075)	1.056*** (0.103)	0.916*** (0.106)	0.898*** (0.025)	1.056*** (0.060)	1.295*** (0.088)	1.538*** (0.111)	1.322*** (0.101)	1.392*** (0.043)	1.538*** (0.067)
<i>Between:</i> Coalition Effect, Non-USD (EUR) Claims ($\tilde{\gamma}_1 + \tilde{\gamma}_4$)	-0.818* (0.464)	-0.367 (0.412)	-0.495 (0.495)	-0.624 (0.407)	-0.367 (0.400)	-0.716 (0.544)	-0.499 (0.513)	-0.532 (0.522)	-0.575 (0.542)	-0.499 (0.500)
Observations	840,654	1,044,335	1,042,489	842,212	1,044,335	620,720	741,090	735,671	625,219	741,090
Bank-Destination-Currency FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Destination-Quarter FE	✓		✓			✓		✓		
Bank-Quarter FE	✓			✓		✓			✓	
Currency-Quarter FE	✓				✓	✓				✓

Notes. The dependent variable is bank claims by destination. Columns (1)–(5) compare claims denominated in all non-USD currencies to claims denominated in USD. Columns (6)–(10) keep only USD and EUR claims and compare EUR-denominated claims to USD-denominated claims. Entries are PPML log coefficients or linear combinations of PPML log coefficients. The reported effects in Panel B are Russia-specific effects relative to other destinations. Standard errors are clustered by bank, destination, and quarter. In the row labels, “Within” denotes currency-category shifts relative to USD within the indicated bank group, while “Between” denotes coalition versus non-coalition comparisons. “Non-USD (EUR)” means non-USD in columns (1)–(5) and EUR in columns (6)–(10). USD and non-coalition banks are the omitted categories. All specifications include the fixed effects reported at the bottom of the table. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.11: Bank Claims on Russia Relative to Other Destinations after the 2014 Sectoral Sanctions: Split by Currency

	(1) EUR	(2) GBP	(3) OTH
Panel A. Estimated Interaction Terms			
Coalition $\times$ Post $\times$ Russia ($\tilde{\gamma}_1$)	-0.243** (0.113)	-0.243** (0.113)	-0.243** (0.113)
Currency $\times$ Post $\times$ Russia ($\tilde{\gamma}_2$)	1.634** (0.651)	0.381 (0.345)	0.298* (0.166)
Currency $\times$ Post $\times$ Coalition ($\tilde{\gamma}_3$)	-0.553 (0.461)	-0.529 (0.545)	0.569** (0.222)
Currency $\times$ Post $\times$ Russia $\times$ Coalition ($\tilde{\gamma}_4$)	-0.331 (0.712)	0.102 (0.357)	-0.078 (0.158)
Panel B. Currency Margin: Claims Relative to USD			
<i>Between:</i> Coalition Effect, USD Claims ($\tilde{\gamma}_1$)	-0.243** (0.113)	-0.243** (0.113)	-0.243** (0.113)
<i>Within</i> Non-Coalition: Column-Currency Shift ($\tilde{\gamma}_2$)	1.634** (0.651)	0.381 (0.345)	0.298* (0.166)
<i>Between:</i> Difference in Column-Currency Shift ($\tilde{\gamma}_4$)	-0.331 (0.712)	0.102 (0.357)	-0.078 (0.158)
<i>Within</i> Coalition: Column-Currency Shift ($\tilde{\gamma}_2 + \tilde{\gamma}_4$)	1.304*** (0.119)	0.483*** (0.134)	0.220** (0.098)
<i>Between:</i> Coalition Effect, Column-Currency Claims ($\tilde{\gamma}_1 + \tilde{\gamma}_4$)	-0.573 (0.687)	-0.140 (0.302)	-0.321** (0.140)
Observations	1,174,646	1,174,646	1,174,646
Sample	All Destinations	All Destinations	All Destinations
Currency Sample	USD vs. EUR, GBP, OTH	USD vs. EUR, GBP, OTH	USD vs. EUR, GBP, OTH
Estimator	PPML	PPML	PPML

Notes. The dependent variable is bank claims by destination. This table reports currency-specific coefficients and linear combinations from the baseline all-destination model with USD, EUR, GBP, and OTH. Bank-Destination-Currency, Destination-Time, Bank-Time and Currency-Time fixed effects included in all specifications. Entries are PPML log coefficients or linear combinations of PPML log coefficients. The effects reported in Panel B are Russia-specific effects relative to other destinations. Standard errors are clustered by bank, destination, and quarter. In the row labels, “Within” denotes shifts in the column currency relative to USD within the indicated bank group, while “Between” denotes coalition versus non-coalition comparisons. The USD coalition effect, $\tilde{\gamma}_1$, is common across the three column-currency contrasts and is repeated for readability. USD and non-coalition banks are the omitted categories. CHF and JPY are not included in this split because of sparse support. All specifications include the fixed effects reported at the bottom of the table. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.12: Geopolitical Distance Quartiles for Selected Countries

Country	2000–2013	2014–2021	2022–2025
Brazil	Q2	Q2	Q2
China	Q4	Q3	Q4
Egypt	Q4	Q4	Q4
Ethiopia	Q3	Q3	Q3
India	Q3	Q2	Q2
Indonesia	Q4	Q4	Q4
Iran	Q4	Q4	Q4
Russia	Q2	Q2	Q3
South Africa	Q3	Q3	Q3
United Arab Emirates	Q4	Q4	Q4

Notes. Quartiles are based on each country's average Bailey ideal-point distance from the United States within each period, ranked against the full processed Bailey country sample for the same period. Q1 denotes the countries closest to the United States; Q4 denotes the countries farthest from the United States.

Table A.13: Spillovers to Non-Russia Destinations: Total Claims, Coalition Banks

	(1) Non-AE/EU	(2) EM	(3) BICS+	(4) BICS
Panel A. Destination Groups				
Post $\times$ Destination $\times$ Coalition	-0.097 (0.257)	0.036 (0.239)	0.360 (0.225)	0.257 (0.202)
Observations	560,130	560,130	560,130	560,130
Pseudo R2	0.965	0.965	0.965	0.965
	(1) Q2	(2) Q3	(3) Q4	
Panel B. Geopolitical-Distance Quartiles				
Post $\times$ Destination $\times$ Coalition	-0.146 (0.232)	-0.116 (0.488)	0.145 (0.354)	
Observations	478,586	478,586	478,586	
Pseudo R2	0.960	0.960	0.960	
Sample	Non-Russia Destinations			
Unit	Bank-Destination-Quarter			
Estimator	PPML			
Bank-Destination FE	✓	✓	✓	✓
Bank-Quarter FE	✓	✓	✓	✓
Destination-Quarter FE	✓	✓	✓	✓

Notes. The dependent variable is total bank claims to non-Russia destinations, collapsed across currencies to the bank-destination-quarter level. Panel A reports destination-group interactions. Panel B reports geopolitical-distance quartile interactions, with Q1 omitted. Entries are PPML log coefficients; standard errors are in parentheses. Standard errors are clustered by bank, destination, and quarter. All specifications include the fixed effects reported at the bottom of the table. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.14: Spillovers to Non-Russia Destinations: Total Claims, Russia-exposed Banks

	(1) Non-AE/EU	(2) EM	(3) BICS+	(4) BICS
Panel A. Destination Groups				
Post $\times$ Destination $\times$ Russia-exposed	0.005 (0.228)	0.261 (0.192)	0.380* (0.227)	0.148 (0.148)
Observations	560,130	560,130	560,130	560,130
Pseudo R2	0.965	0.965	0.965	0.965
	(1) Q2	(2) Q3	(3) Q4	
Panel B. Geopolitical-Distance Quartiles				
Post $\times$ Destination $\times$ Russia-exposed	0.219 (0.166)	0.356 (0.250)	0.500 (0.311)	
Observations	478,586	478,586	478,586	
Pseudo R2	0.960	0.960	0.960	
Sample	Non-Russia Destinations			
Unit	Bank-Destination-Quarter			
Estimator	PPML			
Bank-Destination FE	✓	✓	✓	✓
Bank-Quarter FE	✓	✓	✓	✓
Destination-Quarter FE	✓	✓	✓	✓

Notes. The dependent variable is total bank claims to non-Russia destinations, collapsed across currencies to the bank-destination-quarter level. Panel A reports destination-group interactions. Panel B reports geopolitical-distance quartile interactions, with Q1 omitted. Entries are PPML log coefficients; standard errors are in parentheses. Standard errors are clustered by bank, destination, and quarter. All specifications include the fixed effects reported at the bottom of the table. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.15: Spillovers to Non-Russia Destinations: Total Claims, Coalition $\times$ Russia-exposed Banks

	(1) Non-AE/EU	(2) EM	(3) BICS+	(4) BICS
Panel A. Destination Groups				
Post $\times$ Destination $\times$ Coalition $\times$ Russia-exposed	-0.098 (0.192)	0.098 (0.192)	0.351* (0.195)	0.271 (0.184)
Observations	560,130	560,130	560,130	560,130
Pseudo R2	0.965	0.965	0.965	0.965
	(1) Q2	(2) Q3	(3) Q4	
Panel B. Geopolitical-Distance Quartiles				
Post $\times$ Destination $\times$ Coalition $\times$ Russia-exposed	0.100 (0.153)	-0.010 (0.404)	0.287 (0.255)	
Observations	478,586	478,586	478,586	
Pseudo R2	0.960	0.960	0.960	
Sample	Non-Russia Destinations			
Unit	Bank-Destination-Quarter			
Estimator	PPML			
Bank-Destination FE	✓	✓	✓	✓
Bank-Quarter FE	✓	✓	✓	✓
Destination-Quarter FE	✓	✓	✓	✓

Notes. The dependent variable is total bank claims to non-Russia destinations, collapsed across currencies to the bank-destination-quarter level. Panel A reports destination-group interactions. Panel B reports geopolitical-distance quartile interactions, with Q1 omitted. Entries are PPML log coefficients; standard errors are in parentheses. Standard errors are clustered by bank, destination, and quarter. All specifications include the fixed effects reported at the bottom of the table. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.16: Spillovers to Non-Russia Destinations: Currency Margin, Coalition Banks

	Destination Groups				US-Distance Quartiles		
	(1) Non-AE/EU	(2) EM	(3) BICS+	(4) BICS	(5) Q2	(6) Q3	(7) Q4
Panel A. Estimated Interaction Terms							
BankGroup $\times$ Post $\times$ Destination (γ_1^S)	-0.374** (0.186)	-0.216 (0.200)	-0.099 (0.174)	-0.154 (0.217)	-0.584** (0.235)	-0.676 (0.453)	-0.441* (0.252)
EUR $\times$ Post $\times$ Destination (γ_2^S)	0.722 (0.793)	0.818 (0.841)	-0.170 (0.535)	0.101 (0.511)	-0.438 (0.459)	-0.432 (0.454)	1.455 (1.009)
EUR $\times$ Post $\times$ Destination $\times$ BankGroup (γ_3^S)	-0.277 (0.770)	-0.445 (0.772)	0.769 (0.494)	0.674 (0.522)	0.819* (0.489)	0.835 (0.703)	-0.799 (0.924)
Panel B. Currency Margin: Claims Relative to USD							
<i>Between:</i> BankGroup Effect, USD Claims (γ_1^S)	-0.374** (0.186)	-0.216 (0.200)	-0.099 (0.174)	-0.154 (0.217)	-0.584** (0.235)	-0.676 (0.453)	-0.441* (0.252)
<i>Within</i> Other Banks: EUR Shift (γ_2^S)	0.722 (0.793)	0.818 (0.841)	-0.170 (0.535)	0.101 (0.511)	-0.438 (0.459)	-0.432 (0.454)	1.455 (1.009)
<i>Between:</i> Difference in EUR Shift (γ_3^S)	-0.277 (0.770)	-0.445 (0.772)	0.769 (0.494)	0.674 (0.522)	0.819* (0.489)	0.835 (0.703)	-0.799 (0.924)
<i>Within</i> BankGroup: EUR Shift ($\gamma_2^S + \gamma_3^S$)	0.445*** (0.153)	0.373* (0.210)	0.599** (0.285)	0.775** (0.372)	0.381** (0.159)	0.403 (0.428)	0.656* (0.353)
<i>Between:</i> BankGroup Effect, EUR Claims ($\gamma_1^S + \gamma_3^S$)	-0.650 (0.760)	-0.661 (0.771)	0.671 (0.552)	0.519 (0.579)	0.235 (0.395)	0.159 (0.624)	-1.239 (0.866)
Observations	610,465	610,465	610,465	610,465	519,426	519,426	519,426
Pseudo R2	0.949	0.949	0.949	0.949	0.938	0.938	0.938
Sample	Non-Russia Destinations, EUR vs. USD.						
Bank-Destination-Currency FE	✓	✓	✓	✓	✓	✓	✓
Bank-Quarter FE	✓	✓	✓	✓	✓	✓	✓
Destination-Quarter FE	✓	✓	✓	✓	✓	✓	✓
Currency-Quarter FE	✓	✓	✓	✓	✓	✓	✓

Notes. The dependent variable is bank claims to non-Russia destinations. The table keeps USD and EUR claims and reports spillover currency-margin estimates for BankGroup defined as Coalition. Columns (1)-(4) report destination-group interactions. Columns (5)-(7) report geopolitical-distance quartile interactions, with Q1 omitted. Entries are PPML log coefficients or linear combinations of PPML log coefficients. Standard errors are clustered by bank, destination, and quarter. In the row labels, Within denotes EUR shifts relative to USD within the indicated bank group, while Between denotes comparisons between BankGroup and other banks. Other Banks denotes non-coalition banks. USD and banks outside BankGroup are the omitted categories. All specifications include the fixed effects reported at the bottom of the table. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.17: Spillovers to Non-Russia Destinations: Currency Margin, Russia-exposed Banks

	Destination Groups				US-Distance Quartiles		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Non-AE/EU	EM	BICS+	BICS	Q2	Q3	Q4
Panel A. Estimated Interaction Terms							
BankGroup $\times$ Post $\times$ Destination (γ_1^S)	-0.099 (0.292)	0.331 (0.212)	0.109 (0.174)	-0.004 (0.185)	-0.055 (0.259)	0.173 (0.277)	0.388 (0.315)
EUR $\times$ Post $\times$ Destination (γ_2^S)	0.527 (0.562)	0.987 (0.626)	-0.290 (0.182)	-0.195 (0.294)	-0.363 (0.280)	-0.315 (0.321)	1.621* (0.849)
EUR $\times$ Post $\times$ Destination $\times$ BankGroup (γ_3^S)	-0.042 (0.542)	-0.626 (0.548)	0.979*** (0.305)	1.045** (0.409)	0.805*** (0.278)	0.745 (0.525)	-0.921 (0.778)
Panel B. Currency Margin: Claims Relative to USD							
<i>Between:</i> BankGroup Effect, USD Claims (γ_1^S)	-0.099 (0.292)	0.331 (0.212)	0.109 (0.174)	-0.004 (0.185)	-0.055 (0.259)	0.173 (0.277)	0.388 (0.315)
<i>Within</i> Other Banks: EUR Shift (γ_2^S)	0.527 (0.562)	0.987 (0.626)	-0.290 (0.182)	-0.195 (0.294)	-0.363 (0.280)	-0.315 (0.321)	1.621* (0.849)
<i>Between:</i> Difference in EUR Shift (γ_3^S)	-0.042 (0.542)	-0.626 (0.548)	0.979*** (0.305)	1.045** (0.409)	0.805*** (0.278)	0.745 (0.525)	-0.921 (0.778)
<i>Within</i> BankGroup: EUR Shift ($\gamma_2^S + \gamma_3^S$)	0.484*** (0.168)	0.360 (0.225)	0.690** (0.289)	0.850** (0.347)	0.442*** (0.160)	0.430 (0.367)	0.700* (0.381)
<i>Between:</i> BankGroup Effect, EUR Claims ($\gamma_1^S + \gamma_3^S$)	-0.141 (0.478)	-0.295 (0.541)	1.089*** (0.404)	1.041** (0.529)	0.751*** (0.290)	0.918* (0.468)	-0.533 (0.826)
Observations	610,465	610,465	610,465	610,465	519,426	519,426	519,426
Pseudo R2	0.949	0.949	0.949	0.949	0.938	0.938	0.938
Sample	Non-Russia Destinations, EUR vs. USD.						
Bank-Destination-Currency FE	✓	✓	✓	✓	✓	✓	✓
Bank-Quarter FE	✓	✓	✓	✓	✓	✓	✓
Destination-Quarter FE	✓	✓	✓	✓	✓	✓	✓
Currency-Quarter FE	✓	✓	✓	✓	✓	✓	✓

Notes. The dependent variable is bank claims to non-Russia destinations. The table keeps USD and EUR claims and reports spillover currency-margin estimates for BankGroup defined as Russia-exposed. Columns (1)-(4) report destination-group interactions. Columns (5)-(7) report geopolitical-distance quartile interactions, with Q1 omitted. Entries are PPML log coefficients or linear combinations of PPML log coefficients. Standard errors are clustered by bank, destination, and quarter. In the row labels, Within denotes EUR shifts relative to USD within the indicated bank group, while Between denotes comparisons between BankGroup and other banks. Other Banks denotes banks without positive Russia claims in 2013Q4. USD and banks outside BankGroup are the omitted categories. All specifications include the fixed effects reported at the bottom of the table. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.18: Spillovers to Non-Russia Destinations: Currency Margin, Coalition $\times$ Russia-exposed Banks

	Destination Groups				US-Distance Quartiles		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Non-AE/EU	EM	BICS+	BICS	Q2	Q3	Q4
Panel A. Estimated Interaction Terms							
BankGroup $\times$ Post $\times$ Destination (γ_1^S)	-0.299 (0.232)	-0.029 (0.220)	-0.012 (0.175)	-0.080 (0.204)	-0.221 (0.230)	-0.454 (0.444)	-0.024 (0.296)
EUR $\times$ Post $\times$ Destination (γ_2^S)	0.297 (0.509)	0.601 (0.615)	-0.107 (0.246)	0.074 (0.303)	-0.357 (0.291)	-0.513* (0.309)	1.297 (0.846)
EUR $\times$ Post $\times$ Destination $\times$ BankGroup (γ_3^S)	0.226 (0.482)	-0.184 (0.525)	0.802*** (0.170)	0.794*** (0.233)	0.842*** (0.310)	1.087** (0.502)	-0.557 (0.751)
Panel B. Currency Margin: Claims Relative to USD							
<i>Between:</i> BankGroup Effect, USD Claims (γ_1^S)	-0.299 (0.232)	-0.029 (0.220)	-0.012 (0.175)	-0.080 (0.204)	-0.221 (0.230)	-0.454 (0.444)	-0.024 (0.296)
<i>Within</i> Other Banks: EUR Shift (γ_2^S)	0.297 (0.509)	0.601 (0.615)	-0.107 (0.246)	0.074 (0.303)	-0.357 (0.291)	-0.513* (0.309)	1.297 (0.846)
<i>Between:</i> Difference in EUR Shift (γ_3^S)	0.226 (0.482)	-0.184 (0.525)	0.802*** (0.170)	0.794*** (0.233)	0.842*** (0.310)	1.087** (0.502)	-0.557 (0.751)
<i>Within</i> BankGroup: EUR Shift ($\gamma_2^S + \gamma_3^S$)	0.523*** (0.170)	0.416* (0.226)	0.695** (0.281)	0.868** (0.348)	0.485*** (0.173)	0.574 (0.428)	0.740* (0.378)
<i>Between:</i> BankGroup Effect, EUR Claims ($\gamma_1^S + \gamma_3^S$)	-0.073 (0.427)	-0.213 (0.494)	0.790*** (0.266)	0.714** (0.279)	0.622** (0.276)	0.634** (0.249)	-0.581 (0.738)
Observations	610,465	610,465	610,465	610,465	519,426	519,426	519,426
Pseudo R2	0.949	0.949	0.949	0.949	0.938	0.938	0.938
Sample	Non-Russia Destinations, EUR vs. USD.						
Bank-Destination-Currency FE	✓	✓	✓	✓	✓	✓	✓
Bank-Quarter FE	✓	✓	✓	✓	✓	✓	✓
Destination-Quarter FE	✓	✓	✓	✓	✓	✓	✓
Currency-Quarter FE	✓	✓	✓	✓	✓	✓	✓

Notes. The dependent variable is bank claims to non-Russia destinations. The table keeps USD and EUR claims and reports spillover currency-margin estimates for BankGroup defined as Coalition $\times$ Russia-exposed. Columns (1)-(4) report destination-group interactions. Columns (5)-(7) report geopolitical-distance quartile interactions, with Q1 omitted. Entries are PPML log coefficients or linear combinations of PPML log coefficients. Standard errors are clustered by bank, destination, and quarter. In the row labels, Within denotes EUR shifts relative to USD within the indicated bank group, while Between denotes comparisons between BankGroup and other banks. Other Banks denotes banks that are not both coalition and Russia-exposed. USD and banks outside BankGroup are the omitted categories. All specifications include the fixed effects reported at the bottom of the table. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

A.4 Appendix to the Syndicated Loan Empirical Analysis

A.4.1 Stylised Facts

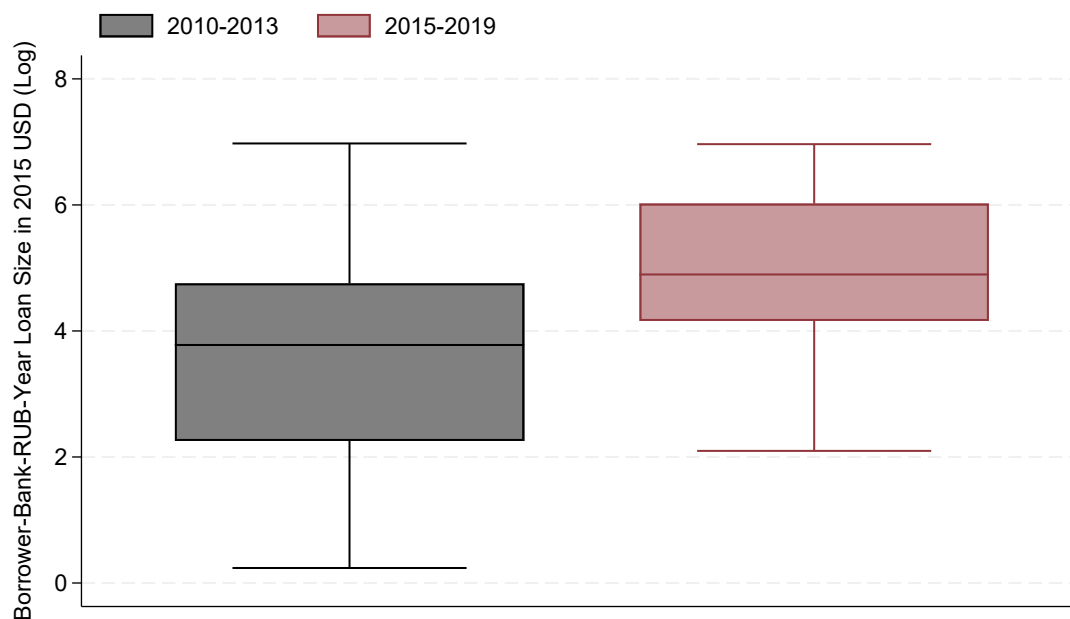


Figure A.12: Russian Syndicated Loans Size Spread In Ruble Before and After 2014.

Note. – Averaged loan size for bank-borrower-currency-year observations on the universe of Russian syndicated loans. Loan size is computed from the US dollar converted tranche amount deflated to 2015 US prices.

Source: DealScan and authors' calculations.

A.4.2 Additional Empirical Evidence

Table A.19: Fixed-Effects Progression for Lender-Jurisdiction and Vehicle-Currency Substitution

	(1) Borrower-Year + Lender	(2) Borrower + Lender-Time	(3) Baseline
Panel A: Lender-Jurisdiction Substitution			
Level Quantity	−0.667* (0.401)	−1.605** (0.646)	−1.358*** (0.354)
Observations	103,897	336,634	87,304
Log Quantity, USD/EUR	0.123 (0.102)	0.308*** (0.114)	0.081 (0.099)
Observations	30,211	27,495	27,237
Log Spread, Priced Loans	−0.007 (0.019)	−0.091 (0.061)	0.007 (0.044)
Observations	17,619	15,772	15,705
Panel B: Vehicle-Currency Substitution			
Level Quantity	2.644*** (0.460)	2.906*** (0.446)	2.776*** (0.455)
Observations	63,916	45,306	45,201
Log Quantity	0.686** (0.342)	0.773** (0.301)	0.674* (0.359)
Observations	33,286	29,586	29,315
Log Quantity, Priced Loans	0.524** (0.267)	1.347*** (0.331)	0.663*** (0.225)
Observations	19,917	17,348	17,277
Log Spread, Priced Loans	−0.143** (0.066)	−0.656** (0.270)	−0.210** (0.087)
Observations	19,917	17,348	17,277

Notes. The table reports the coefficient of interest across alternative fixed-effect structures. Panel A reports the coefficient on $\text{Post} \times \text{Russia} \times \text{Coalition}$. Panel B reports the coefficient on $\text{Post} \times \text{Russia} \times \text{EUR}$. Column (3) is the baseline specification used in the main table. In Panel A, column (1) includes borrower-year and lender fixed effects, column (2) includes borrower and lender-year fixed effects, and column (3) includes borrower-year and lender-year fixed effects. In Panel B, column (1) includes borrower-year, lender, and currency fixed effects, column (2) includes borrower and lender-currency-year fixed effects, and column (3) includes borrower-year and lender-currency-year fixed effects. Level quantity specifications are estimated by PPML. Log quantity and log spread specifications are estimated by OLS. *Priced Loans* denotes observations with reported benchmark spreads. The sample excludes 2014. Standard errors are clustered two-way by lender and borrower-year in Panel A, and by lender and borrower-currency-year in Panel B. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.20: Vehicle-Currency Substitution: Full Coefficients and Contract Controls

	Quantity		Prices		
	Level	Level	Log	Log	Log
	(1)	(2)	(3)	(4)	(5)
Russia $\times$ EUR	−0.985*** (0.169)	−0.912*** (0.183)	0.087** (0.042)	0.076* (0.044)	0.083* (0.044)
Post $\times$ Russia $\times$ EUR	0.690*** (0.191)	0.621*** (0.205)	−0.210** (0.087)	−0.210** (0.084)	−0.214** (0.084)
Log Maturity		−0.611*** (0.175)		0.308*** (0.047)	0.309*** (0.047)
Log Loan Amount					0.007 (0.006)
Observations	17,277	17,188	17,277	17,188	17,188
Russian Post Observations	171	171	171	171	171
Estimator	PPML	PPML	OLS	OLS	OLS
Sample	Priced Loans	Priced Loans	Priced Loans	Priced Loans	Priced Loans
Controls	None	Maturity	None	Maturity	Maturity + Loan Amount

Notes. The table reports the EUR-USD vehicle-currency specification on observations with reported benchmark spreads. The unit of observation is a borrower-lender-currency-year, and the sample excludes 2014. USD is the omitted currency. All columns include borrower-year and lender-currency-year fixed effects. Columns (1) and (2) estimate level loan quantities by PPML. Columns (3)–(5) estimate log benchmark spreads by OLS. Log Loan Amount is included only in price regressions, not in quantity regressions, because it is mechanically related to the quantity outcome. Standard errors are clustered two-way by lender and borrower-currency-year. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.21: Lender-Jurisdiction and Vehicle-Currency Substitution: Within Borrower-Lender

	Quantity				Prices	
	Level	Log	Level	Log	Level	Log
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Lender-Jurisdiction Substitution						
Post $\times$ Russia $\times$ Coalition	−1.567*** (0.586)	0.671*** (0.113)	0.500*** (0.182)	0.501 [†]	−14.39 [†]	−0.082*** (0.027)
Observations	55,448	6,712	4,157	4,157	4,157	4,157
Estimator	PPML	OLS	PPML	OLS	OLS	OLS
Sample	All	All	Priced Loans	Priced Loans	Priced Loans	Priced Loans
	(1)	(2)	(3)	(4)	(5)	(6)
Panel B: Vehicle-Currency Substitution						
Post $\times$ Russia $\times$ EUR	2.958*** (0.512)	0.986** (0.418)	0.771** (0.332)	0.766** (0.321)	−42.62*** (13.33)	−0.169*** (0.064)
Observations	36,248	9,989	6,455	6,455	6,455	6,455
Estimator	PPML	OLS	PPML	OLS	OLS	OLS
Sample	All	All	Priced Loans	Priced Loans	Priced Loans	Priced Loans

Notes. Coalition identifies lenders whose ultimate parent is headquartered in a sanctioning-coalition country. This table repeats the baseline specifications after adding borrower-lender fixed effects, so the estimates compare changes within the same borrower-lender relationship over time. It should therefore be read as a within-relationship robustness check, not as the preferred baseline specification. The unit of observation is a borrower-lender-year in Panel A and a borrower-lender-currency-year in Panel B. The sample excludes 2014. USD is the omitted currency. *All* denotes the main quantity sample for the corresponding specification; *Priced Loans* denotes observations with reported benchmark spreads. Blank cells indicate that the corresponding regression is not estimated in that panel. Standard errors are clustered two-way by lender and borrower-year in Panel A, and by lender and borrower-currency-year in Panel B.

[†] In Panel A, the within borrower-lender estimates in columns (4) and (5) do not have reported standard errors because the clustered variance matrix is singular. The point estimates are shown without standard errors or significance stars.

A.5 Appendix to the Capital Flows View of Geoeconomic Power

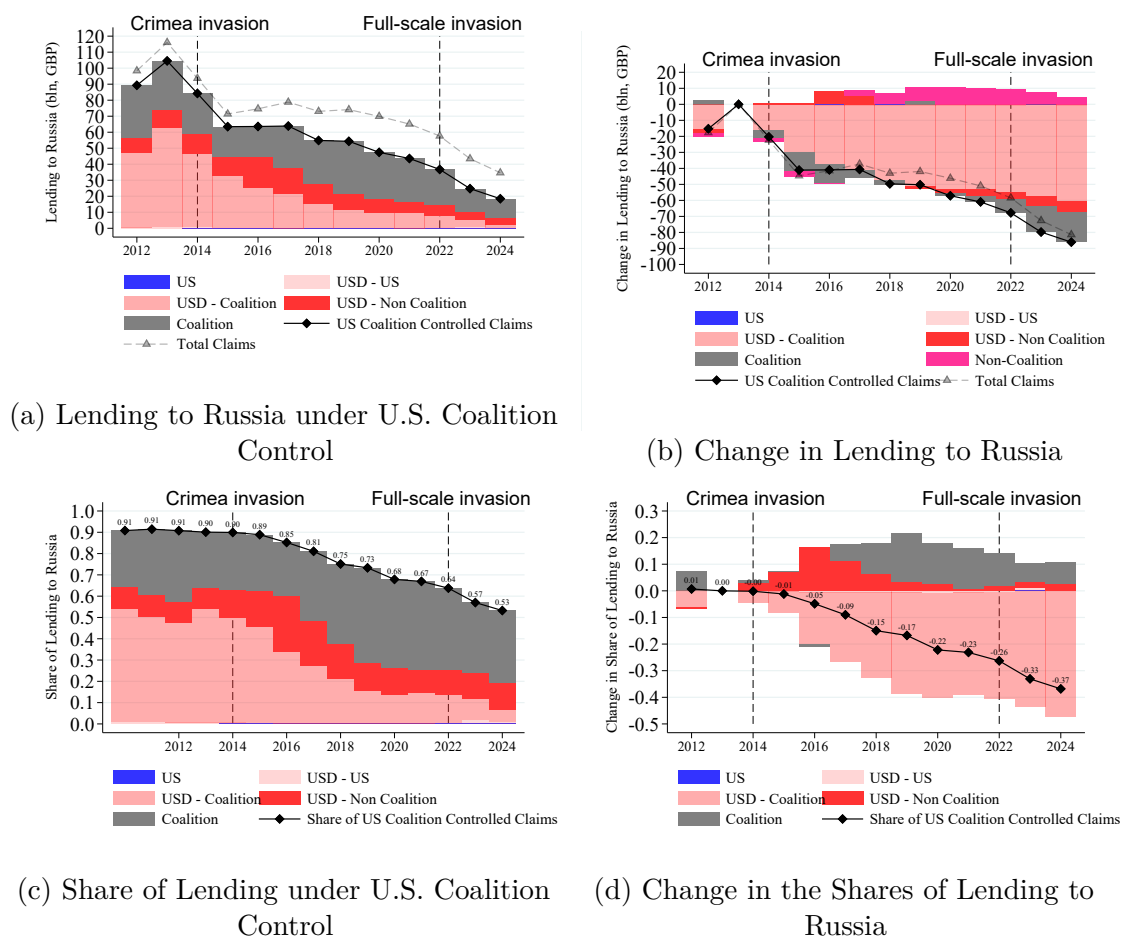


Figure A.13: U.S. Coalition Controlled Claims - Residence Basis.

Note – Amount outstanding of total cross-border claims including all counterparty sectors, all currency, all types of reporting country and all types of instruments. Lending converted from USD into GBP using quarterly averages of spot FX reported by the Bank of England. Some “Other” currencies start to be reported only from 2012Q2. Reporting of claims by Chinese banks starts in 2015 Q4. We match residence aggregates, and assign the difference between total lending to Russia from public BIS data and the sum of the flows plotted here by currencies to the corresponding groups of the non-coalition groups.

Source: BIS locational banking dataset.

B

Appendix to Chapter 2

Contents

B.1 Data: Stylised Facts	195
B.2 Empirics: robustness checks	206

B.1 Data: Stylised Facts

Summary statistics

Year	Firms	Products	Countries	Firm-Product	Firm-Country	Product-Country	Firm-Product-Country
2010	48274	7953	192	263542	19888	149652	477489
2011	48985	7842	190	258510	202327	149463	474933
2012	48967	7837	190	266872	206190	153695	498471
2013	50241	7882	190	284149	216679	162145	543557
2014	50203	7885	189	284407	216366	163106	554732
2015	51276	7886	190	293045	223708	165699	577206
2016	53728	7943	191	321708	240759	172630	642223
2017	54627	8020	190	330714	245015	175787	656254
2018	54739	8016	190	336776	246450	177946	674418
2019	52733	7976	190	340441	246733	180310	695218
2020	48647	7861	189	306495	227597	168088	633182
2021	47905	7843	190	306829	234998	174199	657181
2022	47153	7993	190	315648	236950	179301	683218

Table B.1: Summary statistics (Count).

Source: HMRC administrative datasets, UK non-EU exports, 2010–2022.

Additional facts

In contrast to the exports' patterns shown in Figure 2.1, but in line with what originally reported by Corsetti, Crowley et al. (2022) for the period until 2017, we continue not to observe aggregate behaviour of currency switching when looking at imports up to and including 2022 (Figure 2.2). The GBP value share of UK imports to non-EU countries remained broadly stable at about one third from 2010 to 2022, with USD accounting for 60%. When looking at non-EU non-US imports, shares are unchanged. Importantly, notice how this means that before 2016 the UK was holding a net positive differential position in GBP exports and imports, while net negative in USD. After 2016, the UK now exhibits a considerably less positive and less negative net position in GBP and USD, respectively.

Fact 1 *The aggregate fall in the GBP invoicing is driven by the intensive rather than extensive margin at firm-product-destination level.*

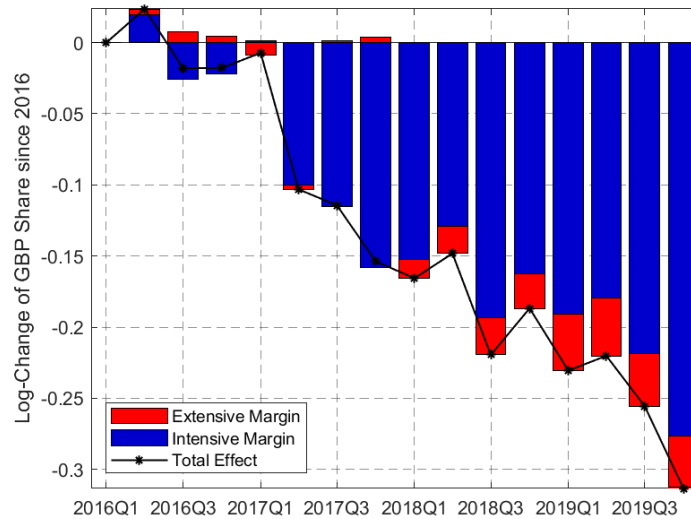


Figure B.1: Intensive/extensive margin decomposition of GBP invoicing shift.

Source: HMRC administrative datasets, UK non-EU exports, 2010–2019.

We investigate what the relevant margins of this change in GBP export invoicing are, that is whether the latter is due to compositional effects or rather it is broad-based across firms. We compute in Figure B.1 how much of the reduction in GBP

invoicing share is due to the extensive margin (or *between* effects) at firm-product-destination level, and how much of it happened because of the intensive margin (or *within* effects). Using the definition of an average, we can define the total export value (in all currencies) in period t as

$$V_t = \bar{V}_t N_t^{f pj} \quad (\text{B.1.0.1})$$

where $N_t^{f pj}$ is the number of individual firm-product-destination triplets, the unit of observation of our dataset, and where $\bar{V}_t$ is the average export value per triplet. Similarly, total export value in GBP in period t is

$$V_t^{\mathcal{L}} = \bar{V}_t^{\mathcal{L}} N_t^{f pj} \quad (\text{B.1.0.2})$$

Taking logs and first differences on both sides yields the decomposition

$$\Delta \ln(V_t) = \underbrace{\Delta \ln(\bar{V}_t)}_{\text{Intensive}} + \overbrace{\Delta \ln(N_t^{f pj})}^{\text{Extensive}} \quad (\text{B.1.0.3})$$

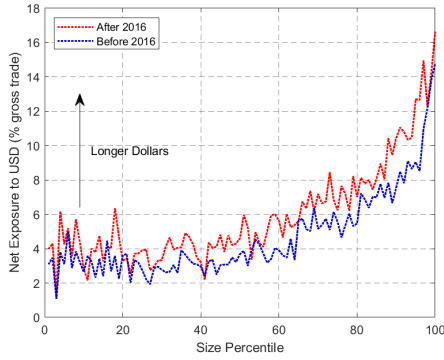
and similarly

$$\Delta \ln(V_t^{\mathcal{L}}) = \Delta \ln(\bar{V}_t^{\mathcal{L}}) + \Delta \ln(N_t^{f pj}) \quad (\text{B.1.0.4})$$

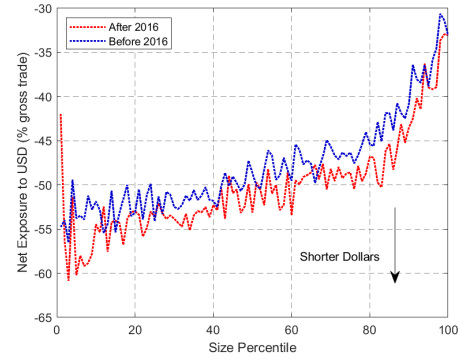
We can further decompose the extensive component in its individual elements (change in destinations, change in product composition, firm entry/exits), but we find that these individual margins do not contribute much respectively. Therefore, for clarity of exposition we plot their aggregate version in Figure B.1, which presents the contribution of intensive and extensive margins to GBP value drop since 2016.

The main message from Figure B.1 is clear. The reduction in the share of GBP invoicing is a result of firm-product-destination triplet flows switching away from pounds, rather than a compositional artefact of our sample. This is important for our empirical identification strategy below which relies on firms actively deciding to change their currency of invoicing, as we will show in Section 2.3.

Fact 2 *The shift towards USD invoicing occurs along the entire firm size distribution, although bigger shifts are associated with larger firms and higher pre-2016 GBP exposure.*



(a) Firms whose exports > imports.



(b) Firms whose imports > exports.

Figure B.2: Net exposure to USD (in % of gross trade) by trade size distribution.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

Let us define the net exposure of a firm to the USD as its exports in USD minus imports in USD in a period, as a proportion of total gross trade. Furthermore, let us dub as (mainly) exporters the firms whose exports in a given period exceed imports. Figure B.2 plots net exposure as a function of firm size (total export value) percentiles, separately for exporters and non-exporters. We see that, in general, the average exporter in each bin is positively exposed to the USD, meaning that its USD exports exceed imports. We also see that the bigger the exporter, the larger the exposure. Crucially, after 2016 (blue line) we observe an upward parallel shift of the distribution, as firms of all sizes have increased their exposure to the USD.

Interestingly, Figure B.2a paints a picture rather different compared to the case of France as described by Barbiero (2022). French exporters at the left tail of the size distribution tend to exhibit perfect hedging, with net exposure to the USD hovering around 0.

In contrast to the case of exporters, Figure B.2b shows very little change occurring for non-exporters, as they lack the margin of adjustment on the side of revenues, where a firm can exercise its currency decision, while on the inputs' side a firm is usually currency-taker. Furthermore, we see that net exposure is negative at every percentile of the distribution for non-exporters. This follows from the fact that imports are predominantly invoiced in USD, and that for these firms imports exceed exports.

Finally, we ask how size and exposure correlate with the observed reduction in GBP share of invoicing. Is the shift more marked for larger or previously more exposed firms? Figure B.3a and B.3b shed light on this question. We can observe a clearly negative relationship between average size/GBP exposure in 2015 and GBP invoicing reduction.¹ Thus, leaders were the ones changing their invoicing away from GBP more markedly. Furthermore, firms exhibiting a more positive exposure to GBP in 2015, that is before the Brexit referendum and the consequent large pound depreciation, switched away from pound the most with respect to other exporters.

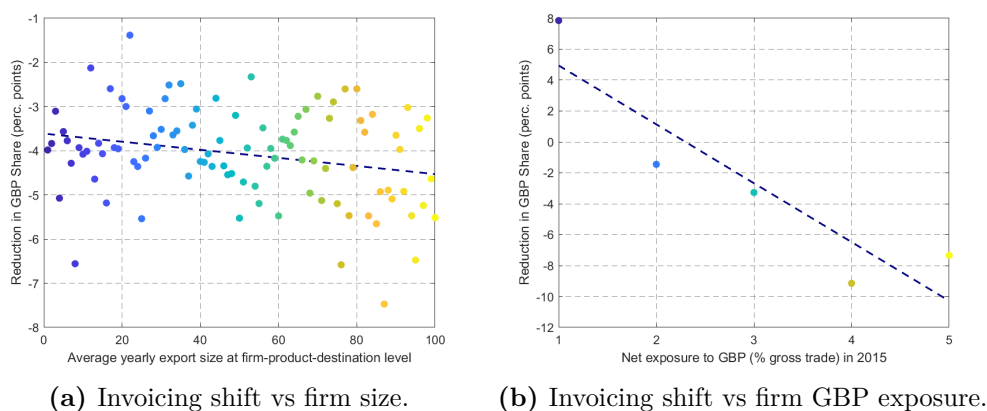


Figure B.3: Correlates of the invoicing shift.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

Fact 3 *The EUR value share of UK exports to non-EU countries increased from about 4% in 2015 to 8% in 2022.*

We report in Figure B.4 the shares of UK exports accounted by the euro. Over our whole sample, the role played by the euro as a vehicle currency is small compared to the USD. However, we observe a twofold increase in the euro share since 2016, from 4% to 8% towards non-EU destinations.

¹These findings are robust to adding one variable as a control for the other before plotting the residuals.

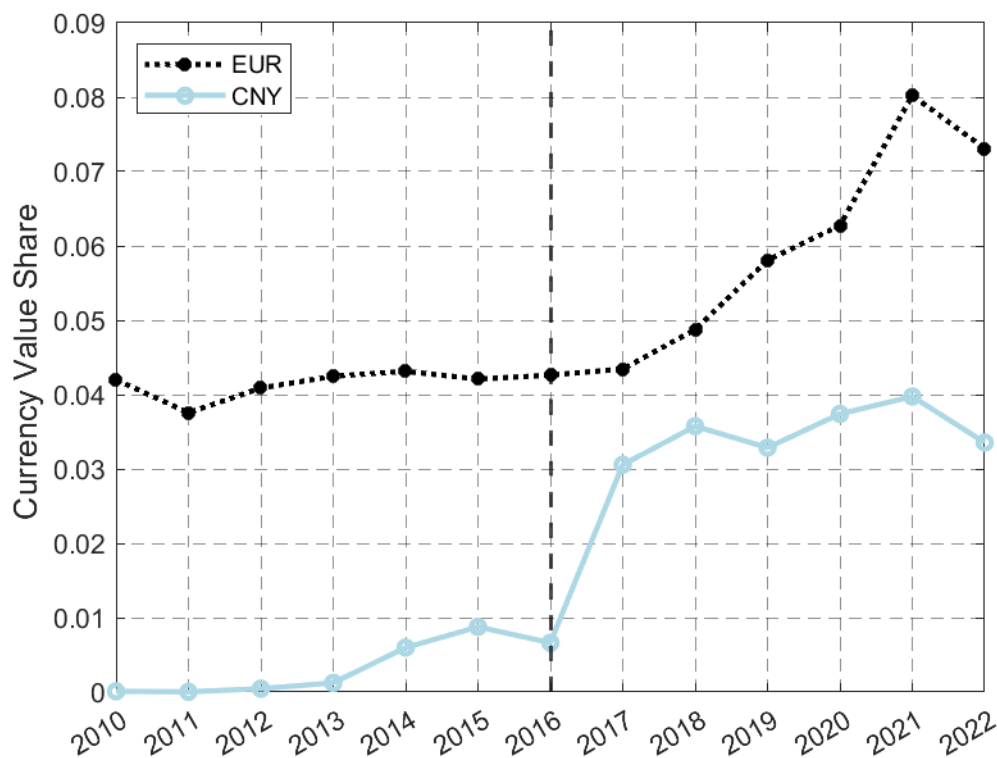


Figure B.4: Currency share of UK non-EU non-US exports.

Source: HMRC administrative datasets, UK non-EU non-US exports, 2010–2022.

Market Power

Figure B.5 reports the distribution of market shares of UK firms at pj (product-destination) level, calculated according to the methodology in subsection 2.4.4.

Construction of Granular firm-level exchange rates

The figures in this subsection underscore the intermediate steps in the construction of the granular effective firm-level exchange rates. From Figure B.6 we can see that on average the largest export destination of a firm accounts for 60% of that firm's total exports. Figure B.7 plots the average granular effective exchange rate series across firms, along the time series dimension.

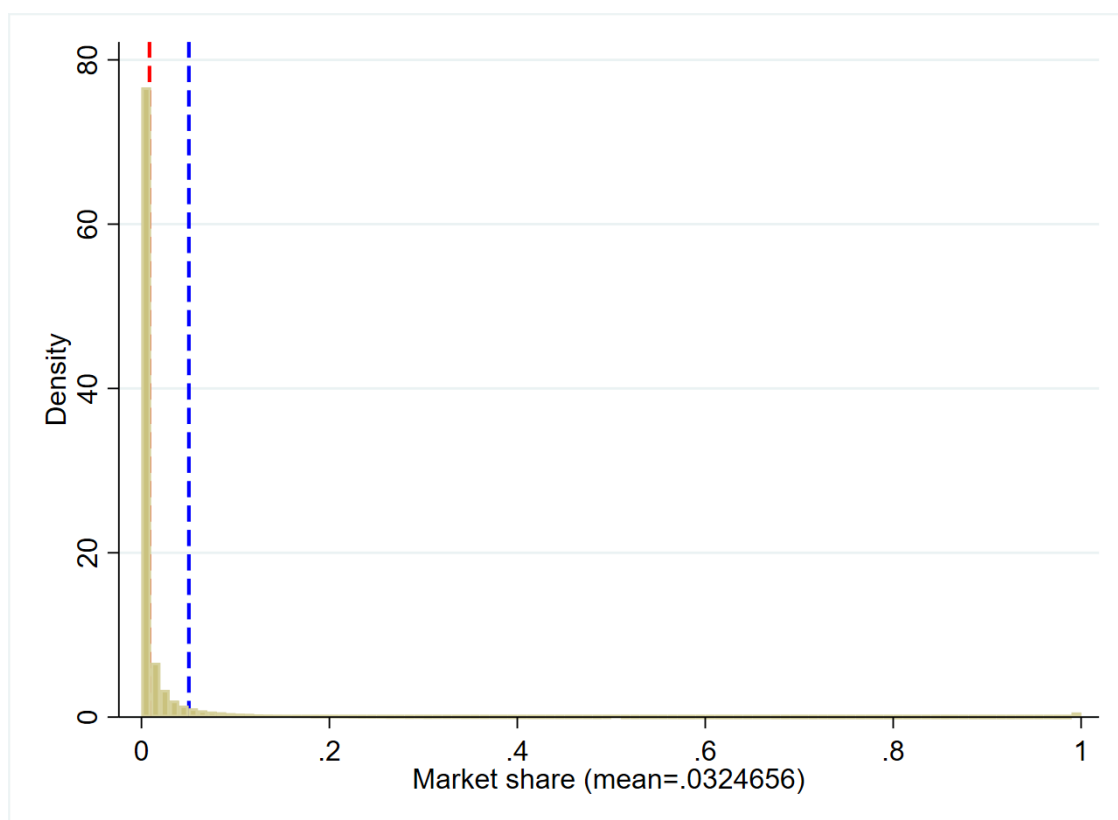


Figure B.5: Distribution market shares.

Source: UN Comtrade and HMRC administrative datasets, UK non-EU exports, 2010–2022.

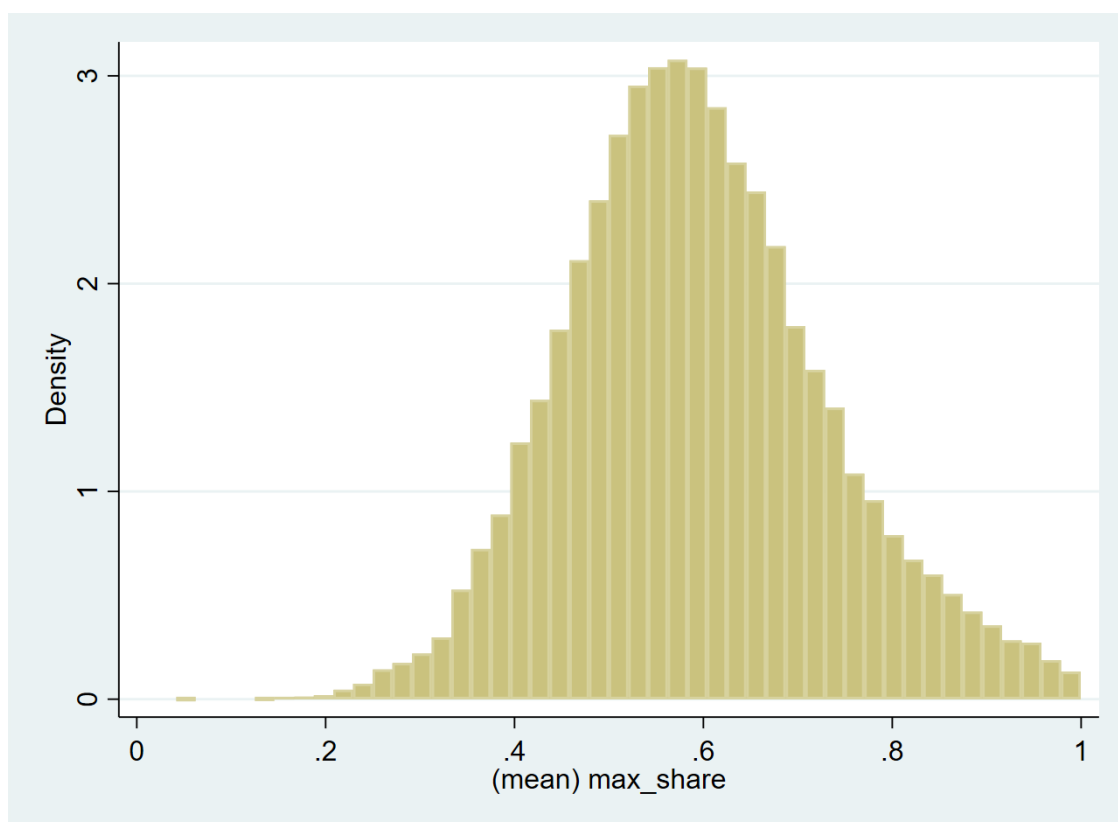


Figure B.6: Distribution top shares.

Source: BIS and HMRC administrative datasets, UK non-EU exports, 2010–2019.

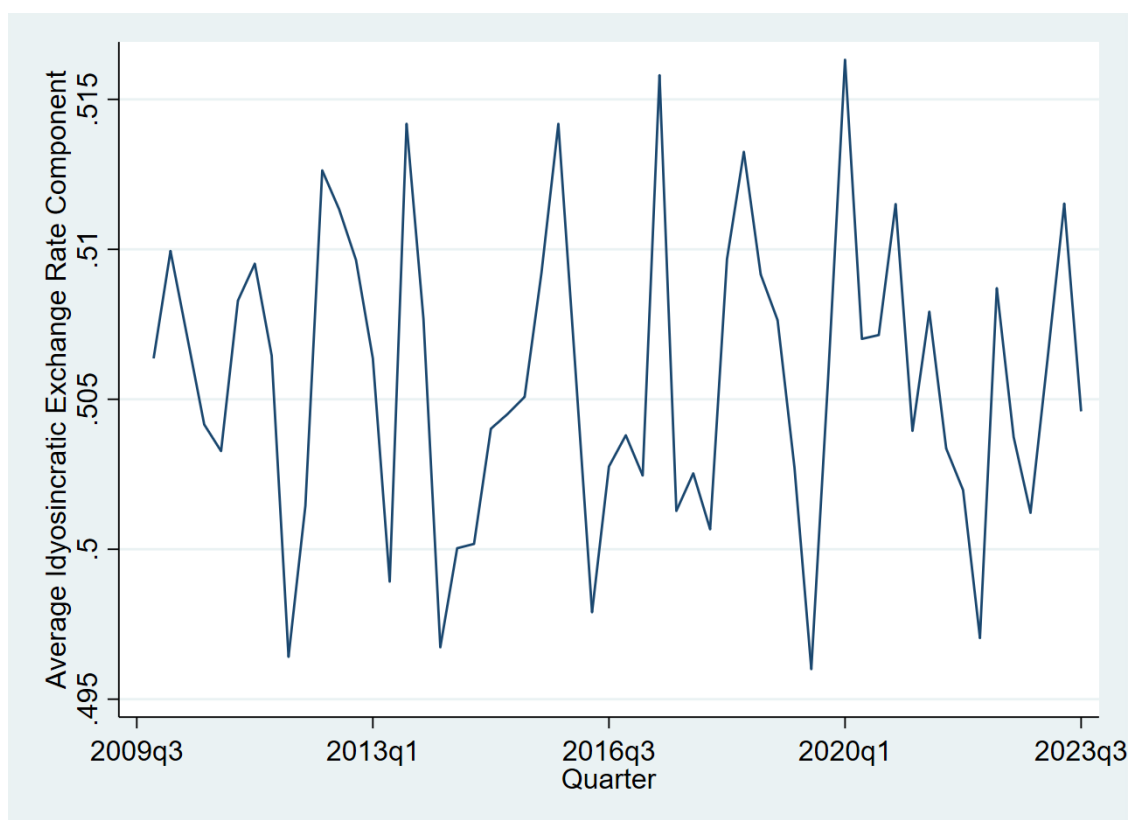


Figure B.7: Shocks GIV.

Source: BIS and HMRC administrative datasets, UK non-EU exports, 2010–2019.

Additional exposure measures

We can construct additional exposure indeces looking at the difference between currencies other than GBP and/or GBP exchange rate with other currencies:

$$s_{ft}^j = \frac{\sum_j (exp_{fj,2015}^j - imp_{fj,2015}^j) \times \Delta e_t^{\mathcal{L}/j}}{Total\ Trade_{f,2015}} \quad (Local\ Weighted\ Index)$$

$$s_{ft}^{\$} = \frac{\sum_j (exp_{fj,2015}^{\$} - imp_{fj,2015}^{\$}) \times \Delta e_t^{\mathcal{L}/\$}}{Total\ Trade_{f,2015}} \quad (Dominant\ Weighted\ Index)$$

$$s_{ft}^{\$,j} = \frac{\sum_j (exp_{fj,2015}^{\$,j} - imp_{fj,2015}^{\$,j}) \times \Delta e_t^{\mathcal{L}/\$}}{Total\ Trade_{f,2015}} \quad (Dominant-Local\ Weighted\ Index)$$

where $exp_{fj}^{\$}$ and $imp_{fj}^{\$}$ indicates respectively the exports and imports of firm f to destination j in 2015 denominated in USD, as a share of gross trade of that firm in that year. With a slight abuse of notation, a superscript j indicates the currency of the destination while a subscript j indicates the country itself. A positive $\Delta e_t^{\mathcal{L}/\$}$ indicates a depreciation of the GBP vis-a-vis the USD. The indices capture the gains/losses from unhedged positions of firms vis-a-vis exchange rates movements. In order to obtain the indices we aggregate across all destination countries.

B.2 Empirics: robustness checks

All tables and figures in this section report robustness checks on the baseline specification presented in the body of the paper.

Static regressions

Table B.2: Baseline with controls spelt out.

	Value share of exports in					
	GBP	GBP	USD	USD	EUR	EUR
	(1)	(2)	(1)	(2)	(1)	(2)
<i>Panel a. Baseline specification</i>						
Valuation shock $s_{f,t}$	-0.01*** (-6.37)	-0.01*** (-6.02)	0.007*** (4.73)	0.01*** (4.82)	0.003*** (3.85)	0.003** (3.13)
<i>Panel b. Strategic complementarities</i>						
Invoicing of largest firm in HS4		0.02*** (16.79)		0.02*** (17.06)		0.02*** (12.60)
Average invoicing in HS4		0.09*** (10.64)		0.09*** (17.06)		0.15*** (8.94)
<i>Panel c. Firm Market Power</i>						
Market Power		0.04*** (5.33)		-0.05*** (-7.67)		0.01 (1.95)
Market power $\times$ valuation shock		0.03 (0.46)		-0.04 (-0.75)		0.03 (1.16)
<i>Additional valuation controls</i>						
Destination-weighted	0.04** (2.92)	0.03 (1.44)	-0.01 (-0.89)	0.001 (-0.04)	0.002 (0.29)	0.006 (0.74)
Dominant-weighted	-0.03*** (-5.04)	-0.03*** (-4.71)	0.04*** (6.68)	0.04*** (5.80)	-0.005* (-2.32)	-0.004 (-1.23)
Dominant-destination weighted	-0.04*** (-8.08)	-0.04*** (-6.60)	0.04*** (7.14)	0.05*** (6.18)	-0.001 (-0.57)	-0.001 (-0.73)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time x Gap FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,322,378	724,482	1,322,378	724,482	1,322,378	724,482

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

Table B.3: Baseline up to 2022

	Value share of exports in					
	GBP	GBP	USD	USD	EUR	EUR
	(1)	(2)	(1)	(2)	(1)	(2)
<i>Panel a. Baseline specification</i>						
Valuation shock $s_{f,t}$	-0.01*** (-4.76)	-0.01*** (-5.20)	0.007*** (4.99)	0.01*** (4.82)	0.001 (3.85)	0.0006 (0.60)
<i>Panel b. Strategic complementarities</i>						
Invoicing of largest firm in HS4		0.02*** (20.16)		0.02*** (20.74)		0.02*** (15.82)
Average invoicing in HS4		0.10*** (12.03)		0.09*** (12.92)		0.15*** (9.82)
<i>Panel c. Firm Market Power</i>						
Market Power		0.05*** (5.33)		-0.06*** (-7.67)		0.01* (1.95)
Market power $\times$ valuation shock		-0.001 (-0.02)		-0.01* (-0.34)		0.03 (1.02)
Additional valuation controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time $\times$ Gap FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,751,049	1,015,652	1,751,049	1,015,652	1,751,049	1,015,652

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

Table B.4: Baseline with quantity share instead of value share.

	Value share of exports in					
	GBP	GBP	USD	USD	EUR	EUR
	(1)	(2)	(1)	(2)	(1)	(2)
<i>Panel a. Baseline specification</i>						
Valuation shock $s_{f,t}$	-0.01*** (-4.44)	-0.01*** (-5.20)	0.004*** (2.71)	0.01*** (4.82)	0.003*** (3.95)	0.0006 (0.60)
<i>Panel b. Strategic complementarities</i>						
Invoicing of largest firm in HS4		0.02*** (14.92)		0.02*** (14.99)		0.02*** (11.74)
Average invoicing in HS4		0.09*** (10.79)		0.10*** (11.70)		0.14*** (8.26)
<i>Panel c. Firm Market Power</i>						
Market Power		0.04*** (5.22)		-0.05*** (-7.43)		0.01 (1.74)
Market power $\times$ valuation shock		0.03 (0.43)		0.02 (-0.34)		0.01 (0.44)
Additional valuation controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time $\times$ Gap FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,301,000	714,229	1,301,000	714,229	1,751,049	714,229

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

Dynamic event-study

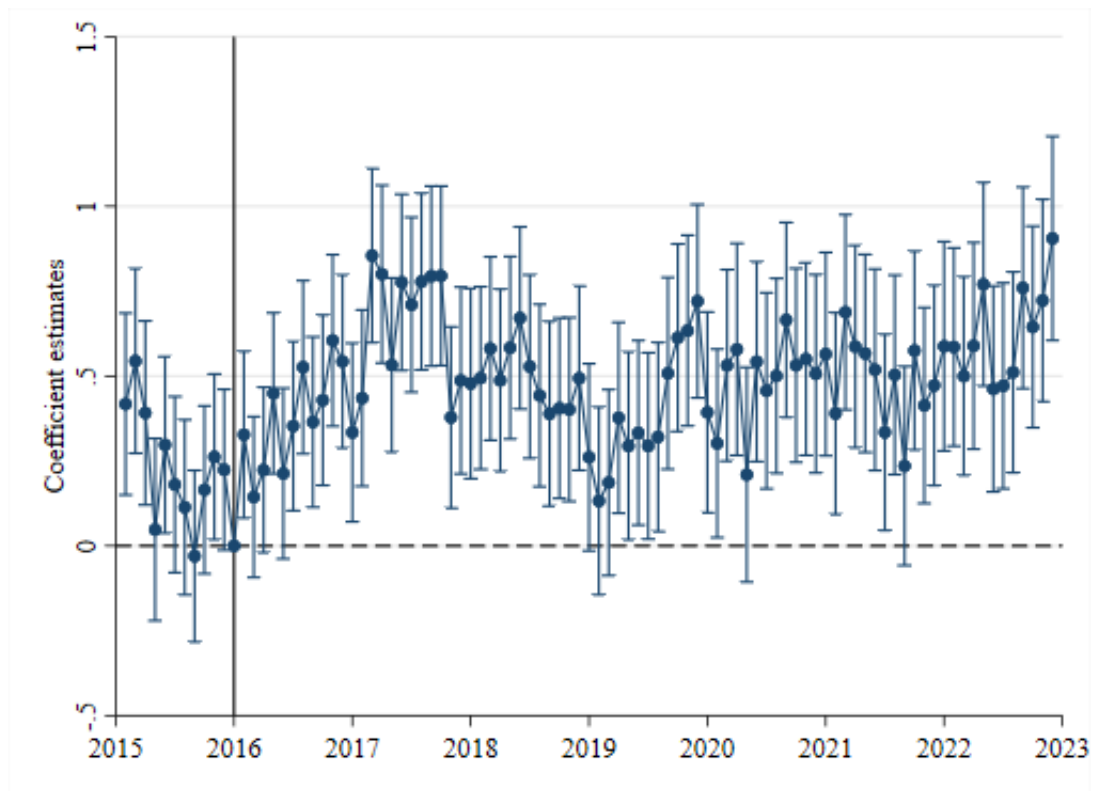


Figure B.8: Event study USD

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

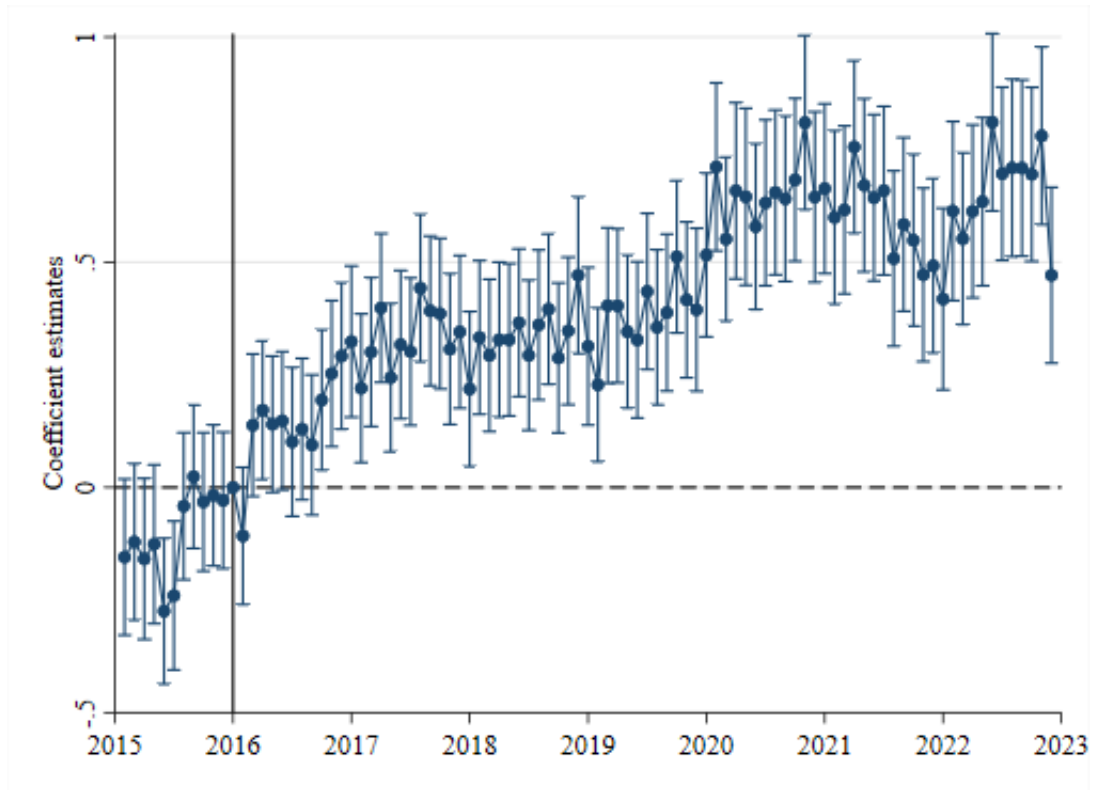


Figure B.9: Event study EUR

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

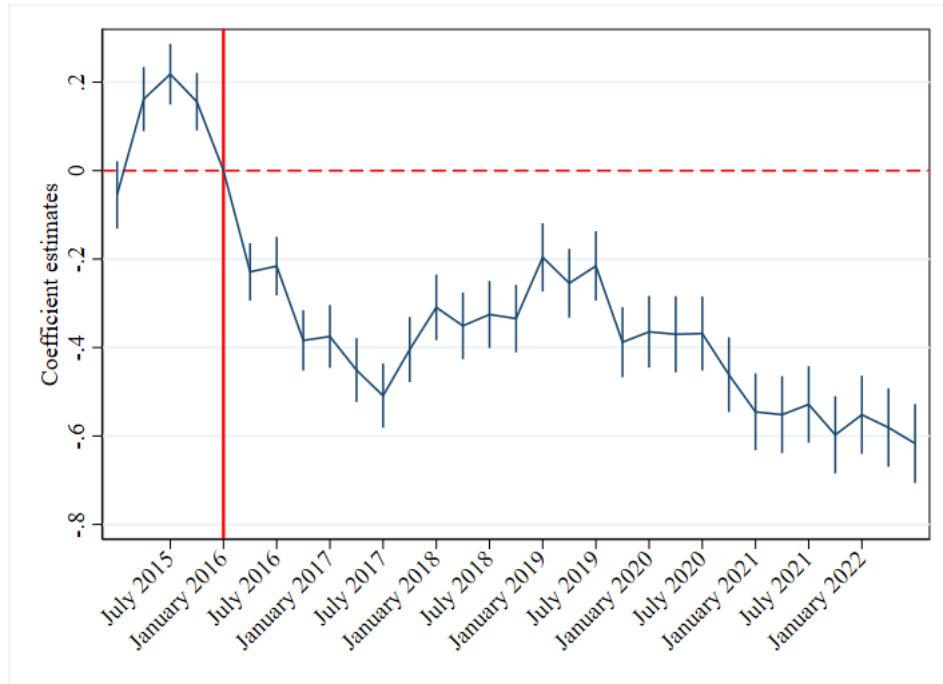


Figure B.10: Event study GBP - quarterly

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

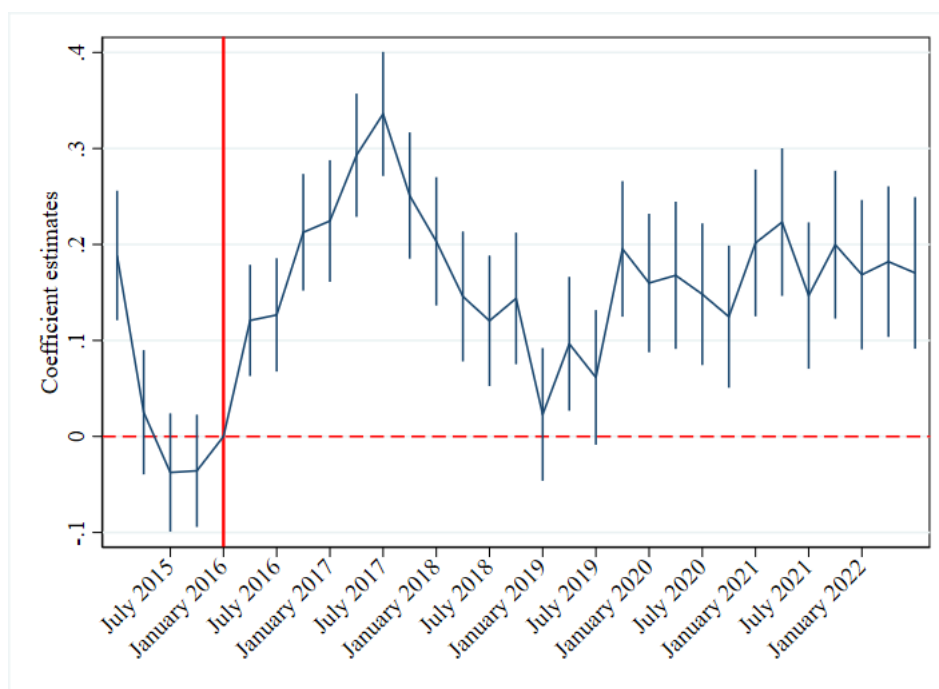


Figure B.11: Event study USD - quarterly

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

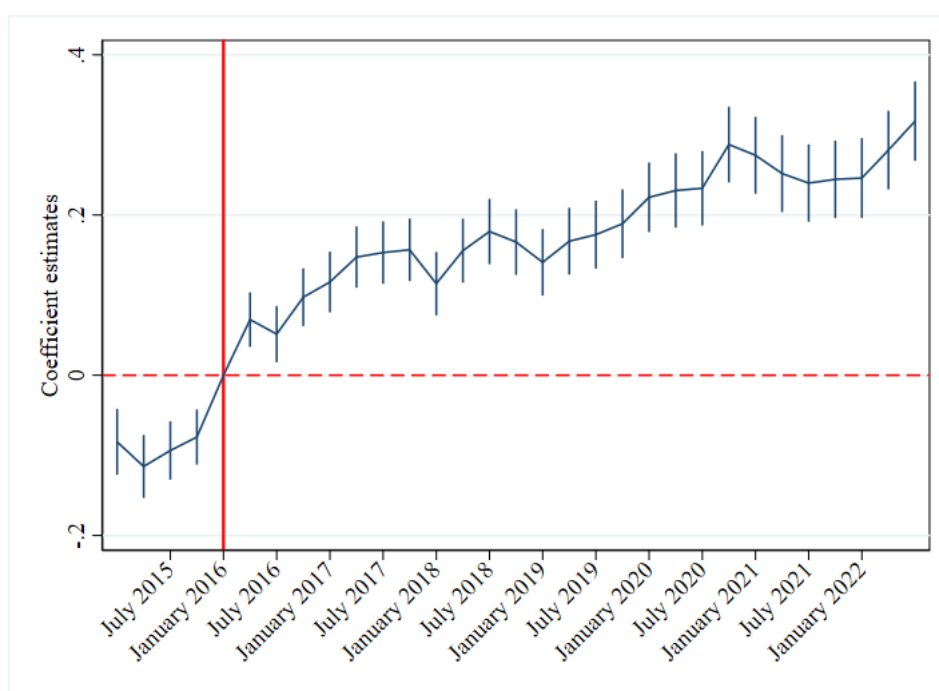


Figure B.12: Event study EUR - quarterly

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

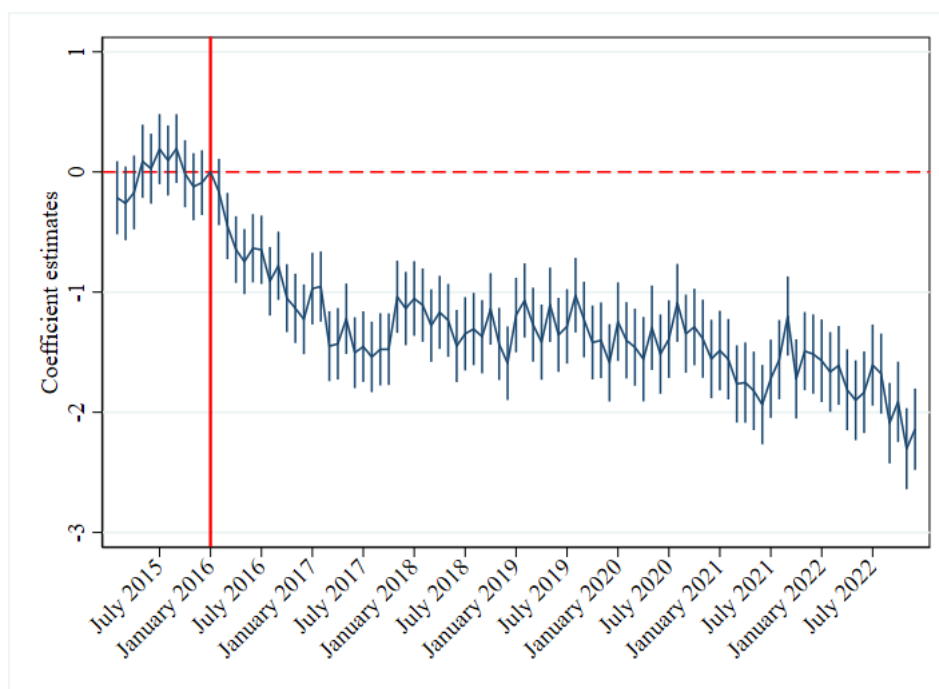


Figure B.13: Event study with exposure in GBP and exports only

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

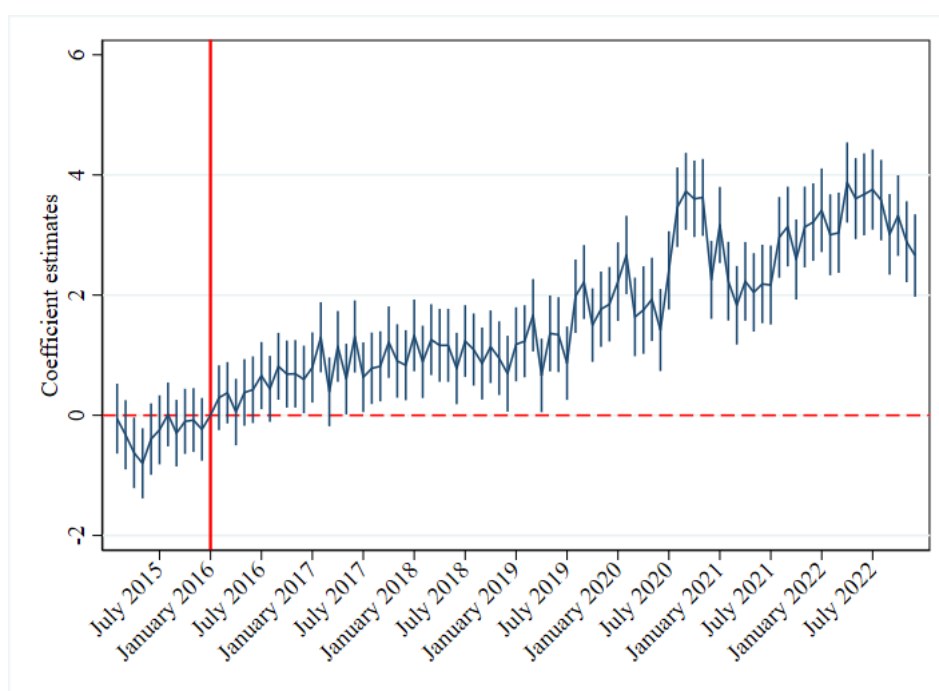


Figure B.14: Event study with exposure in GBP and imports only

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

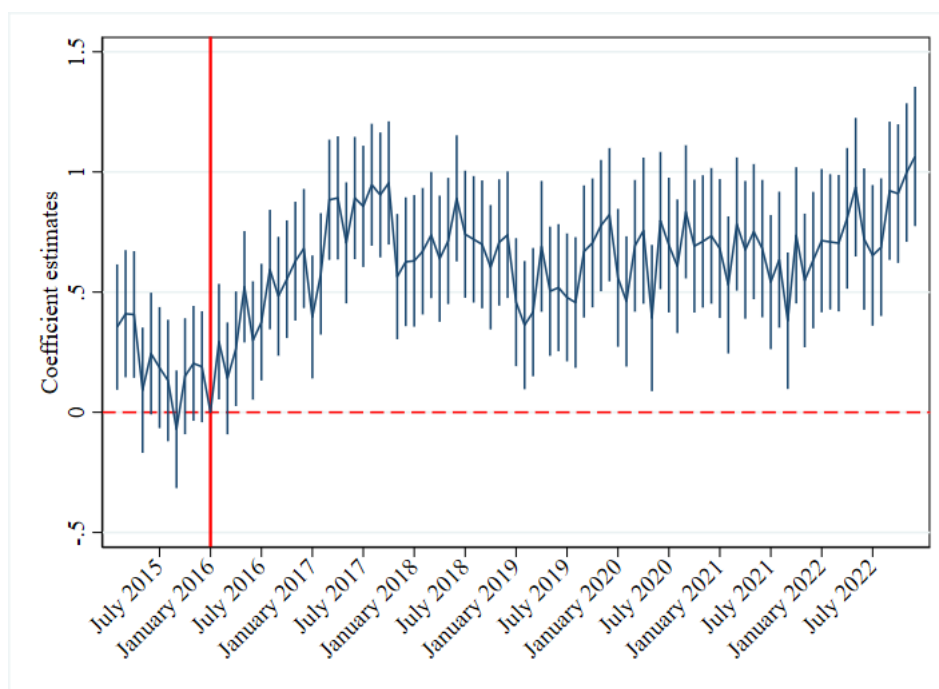


Figure B.15: Event study with exposure in USD and exports only

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

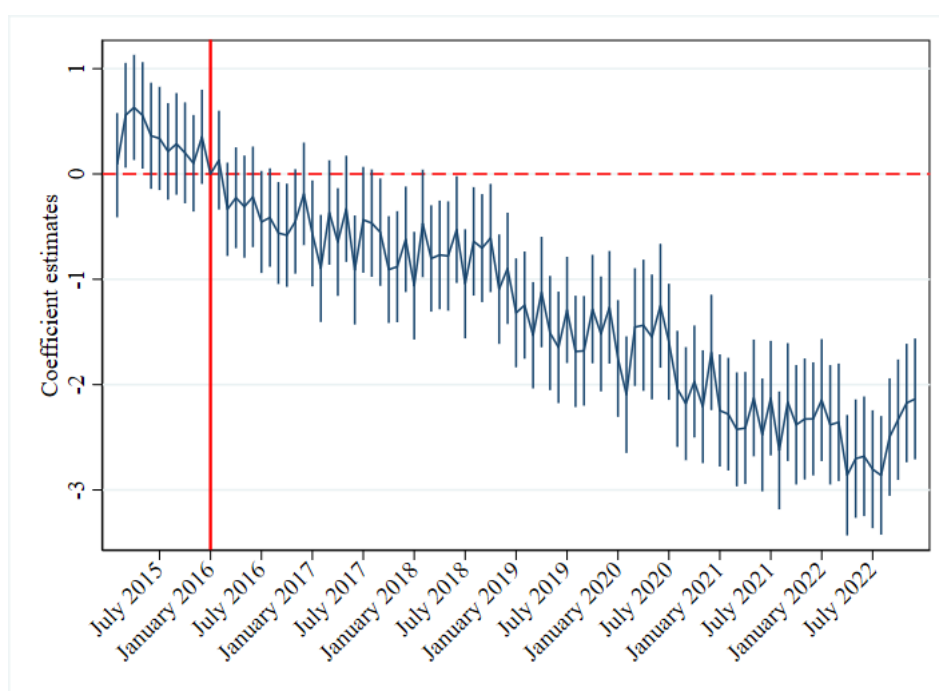


Figure B.16: Event study with exposure in USD and imports only

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

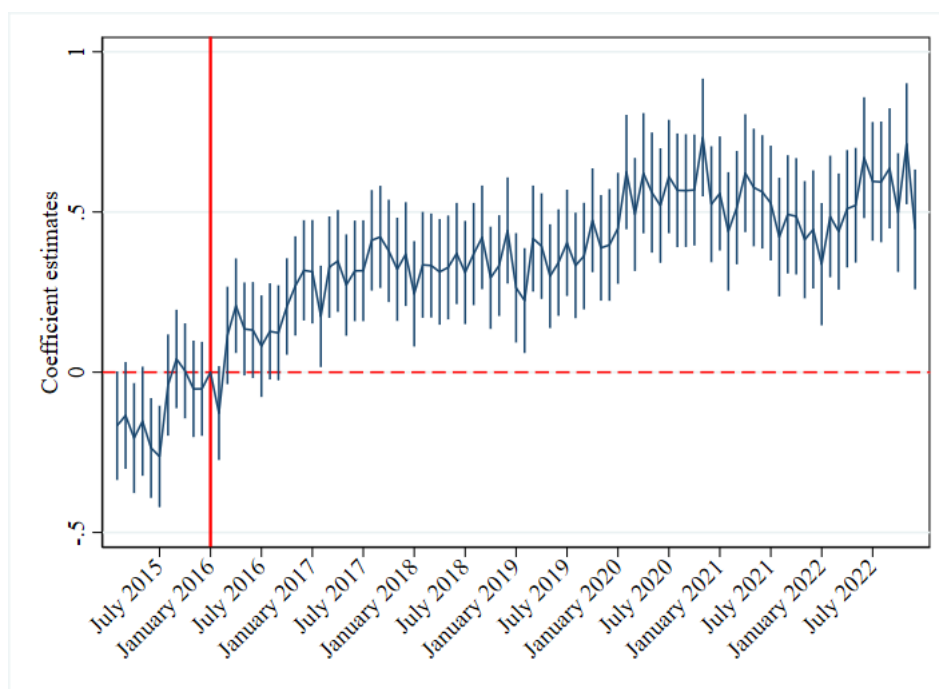


Figure B.17: Event study with exposure in EUR and exports only

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

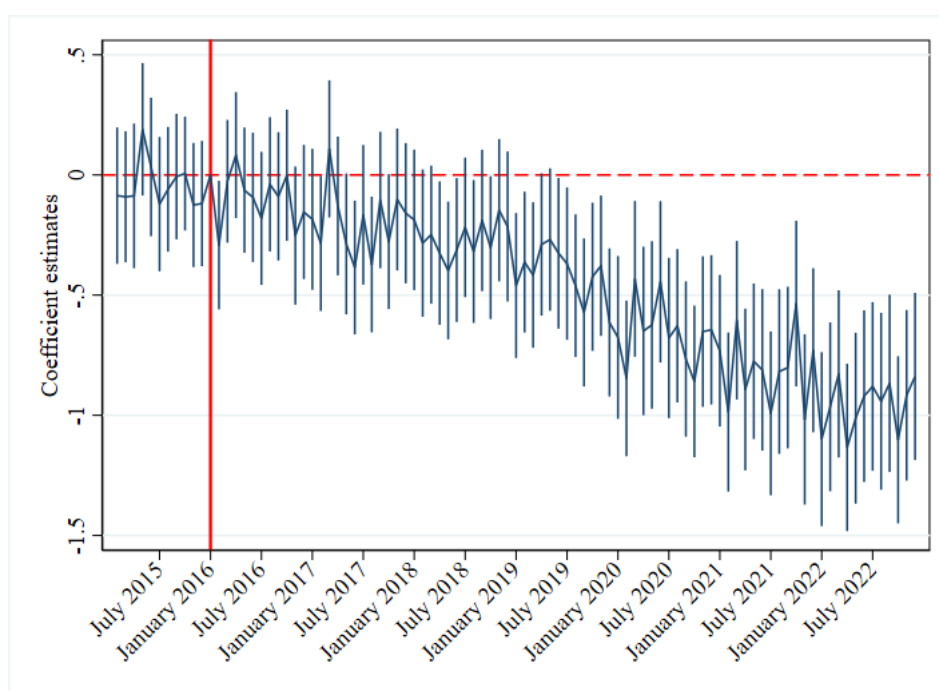


Figure B.18: Event study with exposure in EUR and imports only

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

Back of the envelope at monthly frequency

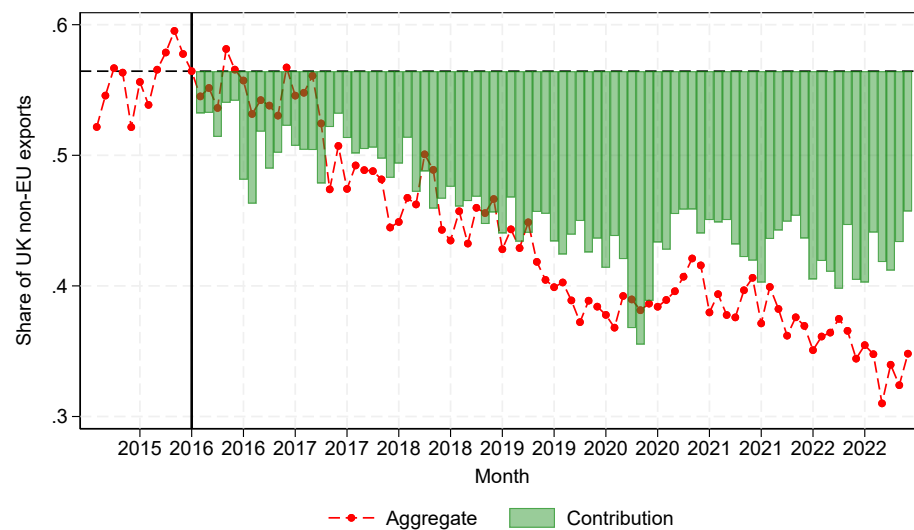


Figure B.19: Hedging channel: contribution to aggregate shift in GBP

Source: HMRC administrative datasets, UK non-EU exports, 2010–2022.

Macroeconomic implications (including years up to 2022)

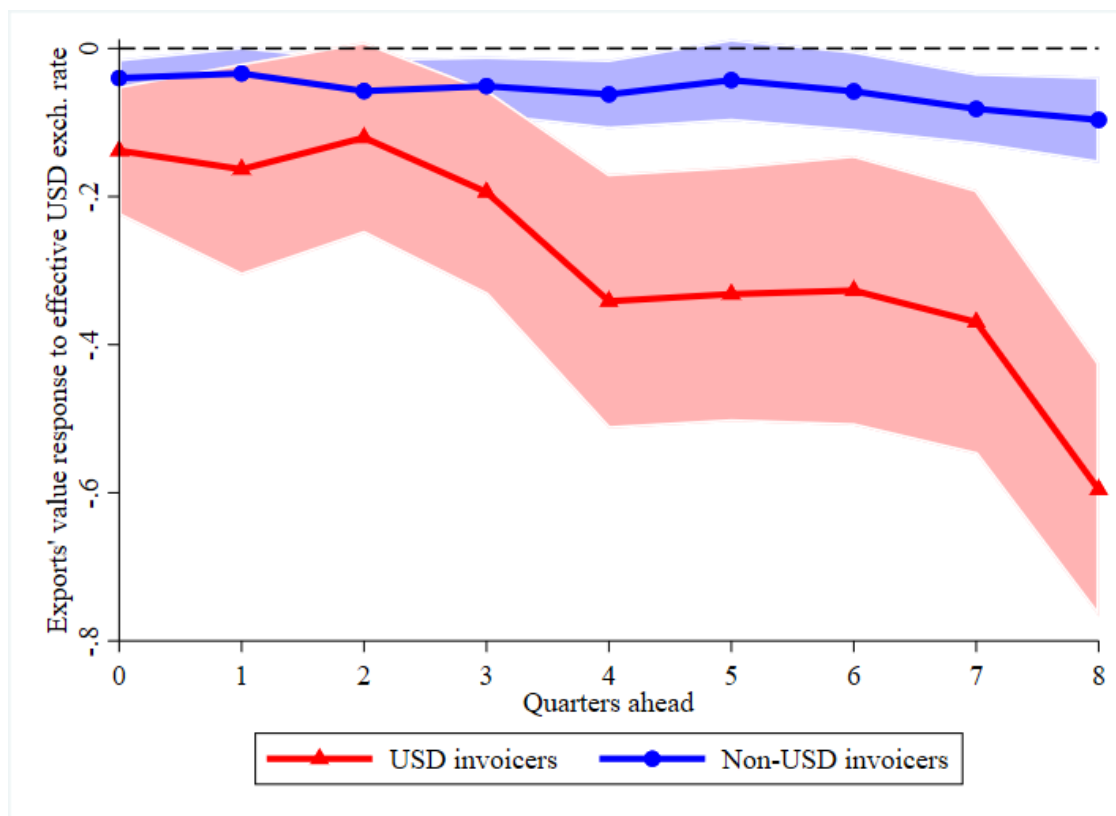


Figure B.20: Dynamic response of export value to appreciation of USD granular exchange rate.

Notes: We exclude US as destination here. **Source:** HMRC administrative datasets, UK non-EU exports, 2010–2022.

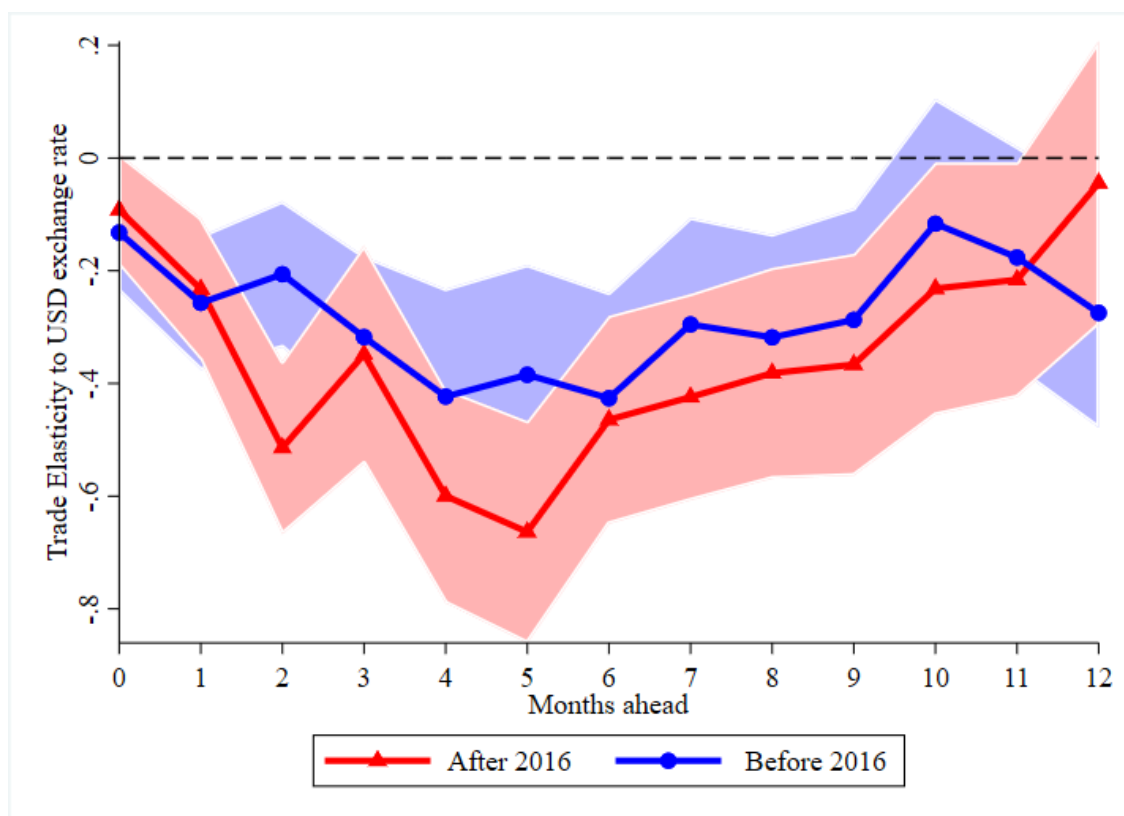


Figure B.21: Dynamic elasticity of export quantities to appreciation of USD.

Notes: We exclude US as destination here. **Source:** HMRC administrative datasets, UK non-EU exports, 2010–2022.

C

Appendix to Chapter 3

Contents

C.1 Data	219
C.1.1 Data sources	219
C.1.2 Data Cleaning	220
C.1.3 Data Coverage	221
C.1.4 Further Summary Statistics	223
C.2 Robustness	225
C.2.1 Monetary Surprises	225
C.2.2 Stock Prices	226
C.2.3 Credit Spreads	234
C.2.4 Debt	241
C.2.5 Investment	247
C.2.6 Mutual Funds	253
C.2.7 Syndicated Loans	257
C.3 Model	261
C.3.1 General Set-Up	261
C.3.2 Green Preferences	261
C.3.3 Pricing Climate Risk	262
C.3.4 Maximisation	262
C.3.5 Brown Premium: Risk and Preferences	263
C.3.6 Sustainable Investing and Monetary Policy	264

C.1 Data

C.1.1 Data sources

Trucost’s Corporate Carbon Emissions I source firm-level information on carbon emissions from Trucost Environmental suite.

Trucost follows four steps to build its data. First, it links company business segments to activities in its model. Next, it creates an estimated profile for each firm using an environmentally extended input/output (EEIO) model. Then, it gathers public data like regulatory filings, sustainability reports, and third-party sources, correcting any detected errors and inconsistencies. Finally, it works with companies to verify that data is accurate across several dimensions.

Compustat I source balance-sheet data from Compustat (North America and Global) Daily Updates - Fundamentals Quarterly via Wharton Research Data Services (WRDS). The time range is from 1961-03 (earliest available) to 2022-08; the data are quarterly and uniquely identified by a firm ID (GVKEY) and year-quarter combination. I screen the panel considering only consolidated accounts, industrial format, standard data format, active and inactive — so there is no “survivor bias” — and calendar (so actual date rather than corresponding fiscal) quarterly entries.

As specified in Section 3.2 in the main text, I trim my Compustat sample in line with related literature. Specifically, I drop financial (SIC 6000-6799) and utilities firms (SIC 4900-4999).

National Accounts I calculate depreciation rates following Ottonello and Winberry (2020) from BEA Interactive Data Tables - National Data - Fixed Assets Accounts Tables.¹ From “Section 3 - Private Fixed Assets by Industry”, the Fixed Assets Tables provide data on the stock, investment, and depreciation of (i) equipment, (ii) structures, and (iii) intellectual property products. These data are disaggregated by NAICS industries. From the stock (in billions of dollars) and

¹<https://apps.bea.gov/iTable>.

the depreciation (in billions of dollars), one can calculate the rate as the ratio of the latter over the former. These series, which are industry specific, are at an annual frequency, starting from 1947 and ending in 2021 (the latest year available). To go from annual to quarterly frequency, one can assume the same depreciation figures within each year, and use the relationship linking the quarterly (δ_{ind}) to the annual ($\delta_{ind,ann}$) depreciation rate:

$$\delta_{ind} = 1 - (1 - \delta_{ind,ann})^{(1/4)} \quad (\text{C.1.1.1})$$

which just comes from

$$1 - \delta_{ind,ann} = (1 - \delta_{ind})^4 \quad (\text{C.1.1.2})$$

i.e. annual *un-depreciation* equals the product of quarterly *un-depreciations*.

C.1.2 Data Cleaning

Following the literature, in particular Ottonello and Winberry (2020), I apply a series of cleaning steps to my dataset.

With the aim to exclude extreme observations or unreasonable values from the final dataset, I make sure that the firm-quarter observations in my sample do not satisfy any of the following conditions:

- Negative capital or assets.
- Investment rate is in the top and bottom 1% of the distribution.
- Net current assets as a share of total assets higher than 10 or below -10.
- Leverage higher than 10 or negative.
- Negative sales or liquidity.

Finally, I winsorise observations of leverage and distance to default at the top and bottom 0.5% of the distribution.

C.1.3 Data Coverage

Table C.1: Country coverage of final sample

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
AUS	87	85	91	97	101	102	105	112	122	186
AUT	15	16	16	17	16	17	17	17	17	17
BEL	23	23	21	24	25	26	26	26	26	28
BRA	52	54	57	60	60	60	61	64	64	64
CAN	91	93	93	94	98	104	108	113	116	115
CHL	11	12	12	12	12	12	12	12	12	12
CHN	53	45	41	49	59	68	739	822	840	885
COL	2	1	1	2	2	3	3	3	3	3
DEU	104	109	108	107	112	118	119	122	124	135
DNK	27	28	30	24	24	25	22	24	26	28
EGY	7	8	7	10	10	11	13	14	14	15
ESP	33	34	33	32	35	37	37	39	40	39
FIN	29	29	31	33	32	34	36	38	41	43
FRA	109	112	114	119	126	133	132	132	134	138
GBR	129	132	132	129	133	136	137	132	136	178
GRC	12	12	12	13	12	13	13	12	12	13
HUN	3	2	2	2	2	2	4	4	3	2
IDN	24	28	26	26	28	29	28	32	31	33
IND	28	131	136	144	159	167	158	159	176	182
ISR	21	25	23	23	24	24	24	24	27	27
ITA	23	25	25	27	30	33	37	38	40	42
JPN	88	88	86	89	94	96	99	102	93	75
KOR	399	340	345	81	63	56	53	47	46	74
MEX	26	27	27	31	31	30	31	34	33	34
MYS	81	87	94	98	103	107	103	105	108	112
NLD	27	27	24	26	30	27	32	32	33	38
NOR	19	17	19	17	18	20	19	21	21	23
NZL	16	19	20	22	24	23	22	27	28	31
PAK	14	15	16	14	14	14	14	16	16	21
PHL	10	12	14	16	19	19	18	19	19	21
POL	21	22	24	24	25	26	27	29	30	32
PRT	6	6	6	7	7	7	7	7	7	6
RUS	4	6	7	7	8	12	16	15	15	17
SWE	68	73	77	76	79	83	87	109	113	141
THA	65	63	64	71	77	80	85	88	90	90
TUR	23	24	29	32	33	33	34	36	37	38
TWN	33	30	38	51	371	433	444	431	439	642
ZAF	43	44	46	44	44	47	51	52	55	60
AEs	1359	1323	1344	1108	1454	1547	1576	1605	1641	2019
G20	1283	1343	1363	1136	1179	1224	1908	2012	2062	2256
G20 - EMEs	253	359	369	393	422	446	1118	1214	1251	1313
G20 - EMEs ex. China	200	314	328	344	363	378	379	392	411	428
EMEs	467	581	603	642	686	720	1397	1504	1546	1621
Oil Producers	114	116	119	118	124	136	143	149	152	155
BRICS	180	280	287	304	330	354	1025	1112	1150	1208

Source: Trucost and author's calculations. Notes: Number of firms. Country groupings follow IMF classification (International Monetary Fund, 2022). For all details on my final sample, please see Appendix C.1.

Table C.2: Sector coverage of final sample

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Accommodation and Food Services	40	38	39	38	45	47	55	52	54	57
Administrative and Support and Waste Management and Remediation Services	33	34	38	41	45	45	55	58	62	74
Agriculture, Forestry, Fishing and Hunting	23	24	24	25	27	25	33	34	34	34
Arts, Entertainment, and Recreation	13	17	19	18	19	19	21	22	22	25
Construction	111	114	117	109	113	120	136	141	142	149
Educational Services	7	7	7	7	8	11	12	14	15	15
Health Care and Social Assistance	20	22	23	25	26	33	42	45	49	54
Information	155	157	154	151	162	172	204	216	231	282
Manufacturing	1007	1066	1100	904	1189	1260	1753	1824	1861	2160
Professional, Scientific, and Technical Services	110	119	130	126	144	155	213	227	240	266
Retail Trade	123	121	113	120	138	148	175	197	195	225
Transportation and Warehousing	87	91	92	95	113	120	140	141	147	149
Wholesale Trade	97	94	91	91	111	112	134	138	135	150

Source: Trucost and author's calculations. Notes: Number of firms. For all details on my final sample, please see Appendix C.1.

C.1.4 Further Summary Statistics

Table C.3: Summary statistics of main firm-level covariates - Scope 2

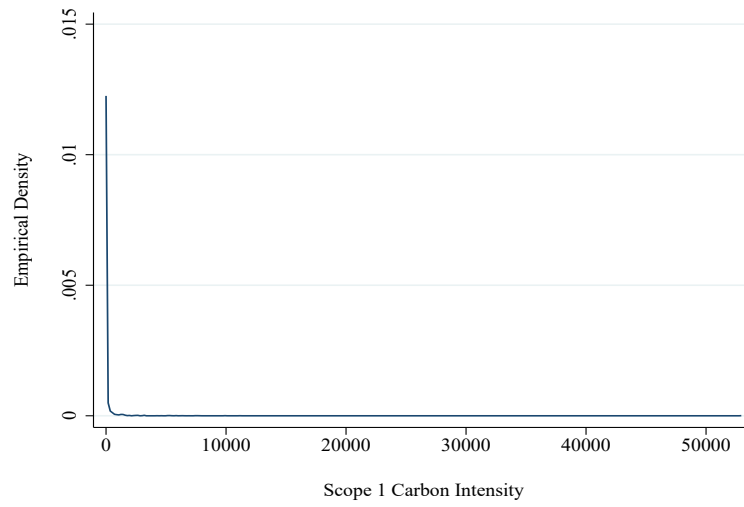
All Firms	Mean	Median	S.D.	95th P.	Max	N
Emissions	260774.37	32364.27	1649857.27	1099009.90	1.56e+08	51379
Emissions/revenues	55.57	23.98	349.67	195.67	41724.72	51379
dlnk	0.01	-0.00	0.06	0.10	0.52	85203
Real sales growth	0.02	0.00	0.31	0.38	10.33	82339
Age	59.62	41.00	57.13	157.00	653.00	50560
Real total assets	6.82	6.76	1.79	9.92	12.84	85203
Current assets ratio	0.47	0.47	0.20	0.81	1.00	85203
Leverage	0.26	0.24	0.18	0.54	6.98	85203
d2d	7.69	6.67	5.24	16.90	81.58	59796
Che assets ratio	0.14	0.10	0.13	0.38	0.98	85134
USD share	0.07	0.00	0.20	0.60	1.00	67046
EUR share	0.02	0.00	0.10	0.01	1.00	67046

Brown Firms	Mean	Median	S.D.	95th P.	Max	N
Emissions	414226.70	60838.47	2280070.67	1908230.00	1.56e+08	26082
Emissions/revenues	88.88	42.94	488.00	283.29	41724.72	26082
dlnk	0.01	-0.00	0.06	0.10	0.52	47456
Real sales growth	0.02	0.00	0.30	0.37	10.33	45923
Age	60.14	41.00	54.80	159.00	409.00	25599
Real total assets	6.76	6.68	1.81	9.86	12.47	47456
Current assets ratio	0.45	0.44	0.20	0.79	1.00	47456
Leverage	0.27	0.26	0.19	0.55	6.98	47456
d2d	7.27	6.33	4.98	15.84	81.58	32909
Che assets ratio	0.13	0.09	0.12	0.35	0.97	47416
USD share	0.07	0.00	0.21	0.62	1.00	37382
EUR share	0.01	0.00	0.09	0.00	1.00	37382

Green Firms	Mean	Median	S.D.	95th P.	Max	N
Emissions	102560.21	18034.22	345359.49	432888.89	8307554.92	25297
Emissions/revenues	21.22	14.78	22.11	56.32	241.38	25297
dlnk	0.01	-0.00	0.06	0.10	0.52	37747
Real sales growth	0.02	0.00	0.33	0.40	9.26	36416
Age	59.08	41.00	59.43	155.00	653.00	24961
Real total assets	6.91	6.85	1.77	10.02	12.84	37747
Current assets ratio	0.49	0.49	0.20	0.84	1.00	37747
Leverage	0.24	0.22	0.17	0.52	4.55	37747
d2d	8.20	7.10	5.50	18.13	69.86	26887
Che assets ratio	0.15	0.11	0.13	0.40	0.98	37718
USD share	0.07	0.00	0.20	0.56	1.00	29664
EUR share	0.02	0.00	0.12	0.03	1.00	29664

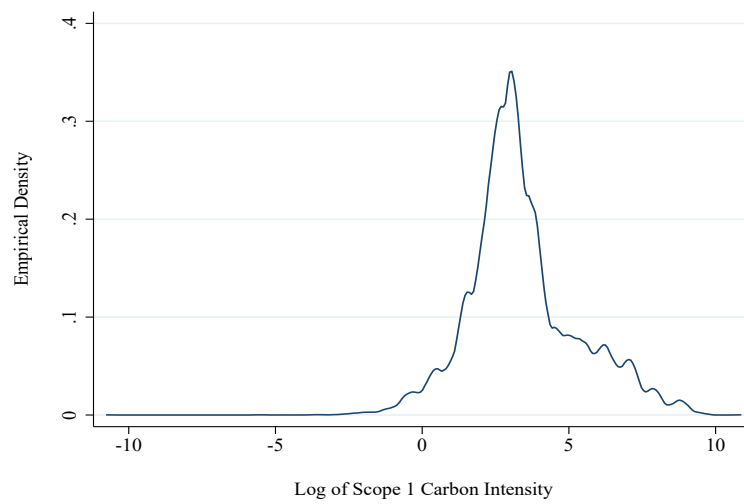
Source: CIQ, Trucost and author's calculations. Notes: Summary statistics of panel of firms from 2010 to 2019. Emission measures refer to Scope 2. Firms are brown (green) if their emission intensity is larger (smaller) than country-sector median across all years. Listed variables from top to bottom: emission levels (tCO₂e); carbon intensity (tCO₂e/\$M); log first-difference change in the (real) firm-level capital stock (decimals); log first-difference change in (real) firm-level sales (decimals); age of the firm (years since foundation); log of real total assets; current assets (share of total assets); debt over assets (share of total assets); distance to default (units of firm's value volatility); cash and short-term investments (share of total assets); USD liabilities (share of total liabilities). For all details on these variables and the cleaning procedures applied to construct my final sample, please see Appendix C.1.

Figure C.1: Density Distribution of Carbon Intensity



Source: CIQ, Trucost and author's calculations. Notes: Panel of firms from 2010 to 2019. Emission measures refer to Scope 1 carbon intensity (tCO₂e/\$M). For all details, please see Appendix C.1.

Figure C.2: Density Distribution of Log of Carbon Intensity

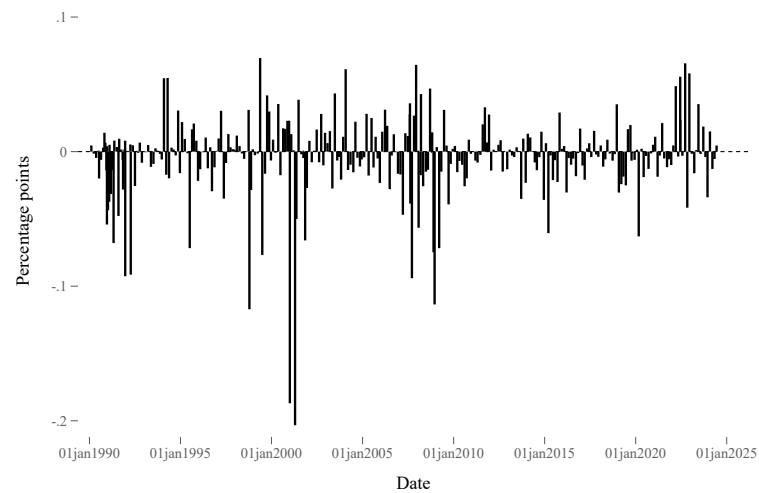


Source: CIQ, Trucost and author's calculations. Notes: Panel of firms from 2010 to 2019. Emission measures refer to the log of Scope 1 carbon intensity (tCO₂e/\$M). For all details, please see Appendix C.1.

C.2 Robustness

C.2.1 Monetary Surprises

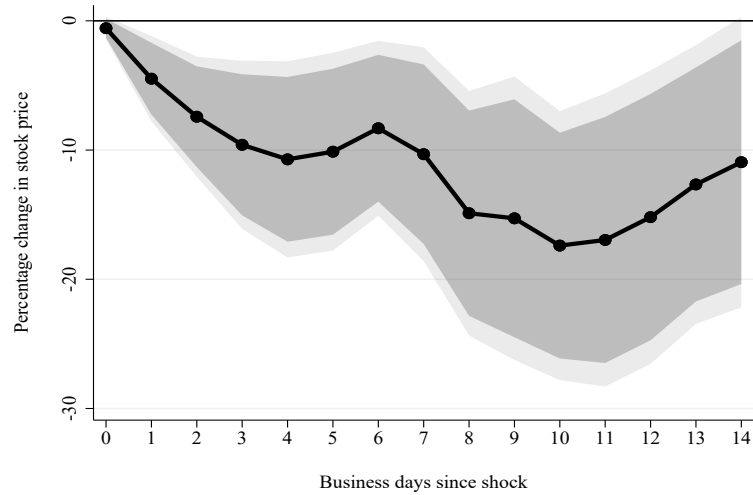
Figure C.3: Monetary policy surprises on Fed announcement dates: Median rotation series



Notes: Monetary policy shocks for the period 2010 to 2019, normalised by the market yield on US Treasury securities at 1-year constant maturity. The shock series is based on the “Median Rotation” high frequency monetary policy surprises robust to information effects from Jarociński and Karadi (2020).

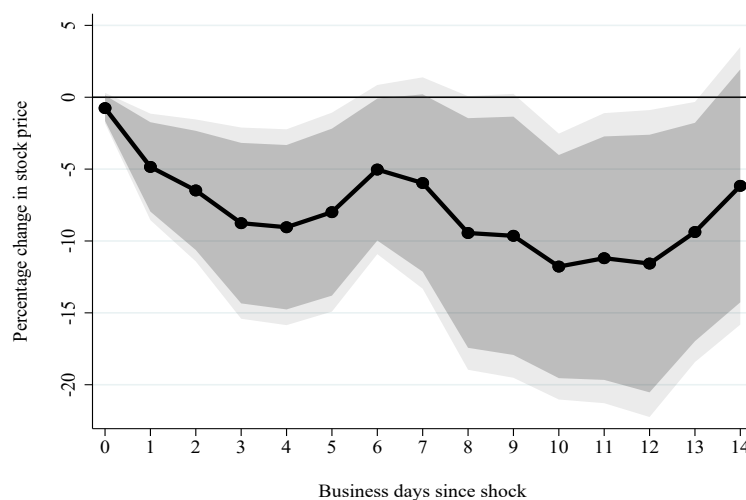
C.2.2 Stock Prices

Figure C.4: Response of non-US stock prices to US monetary policy: Average effect



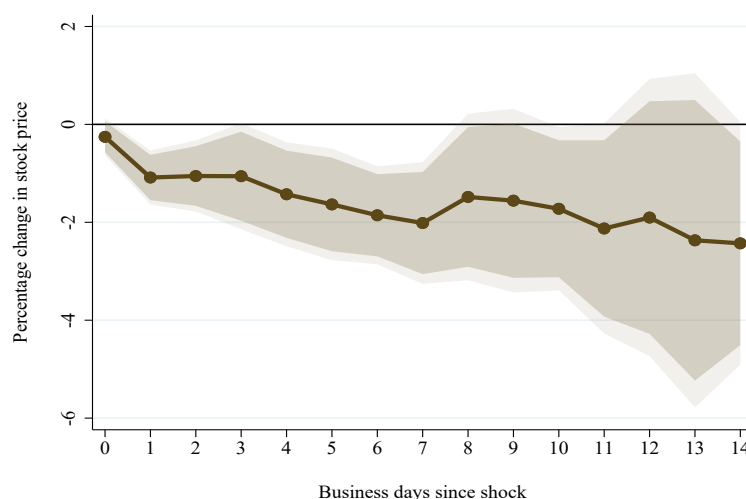
Notes: Dynamics of the coefficient on monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients for the average effect of equation (3.3.1.1) dropping time fixed effects. Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.5: Response of non-US stock prices to US monetary policy: Average effect - Advanced Economies only



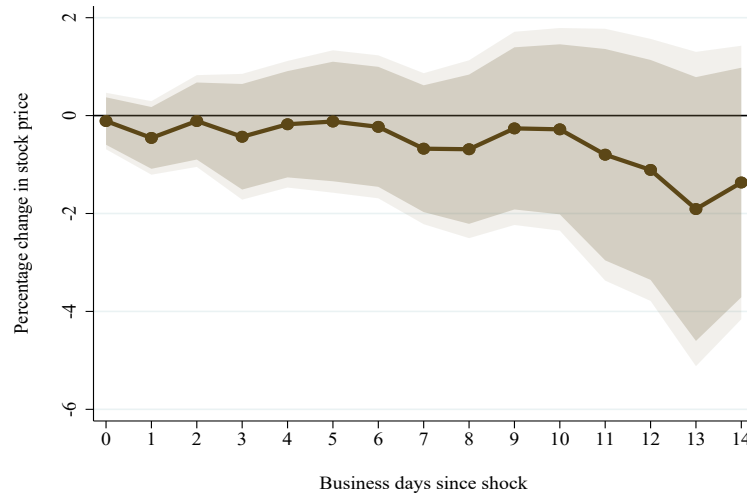
Notes: Dynamics of the coefficient on monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients for the average effect of equation (3.3.1.1) dropping time fixed effects. Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.6: Response of non-US stock prices to US monetary policy (“Median Rotation” shocks): Scope 1 emission intensity



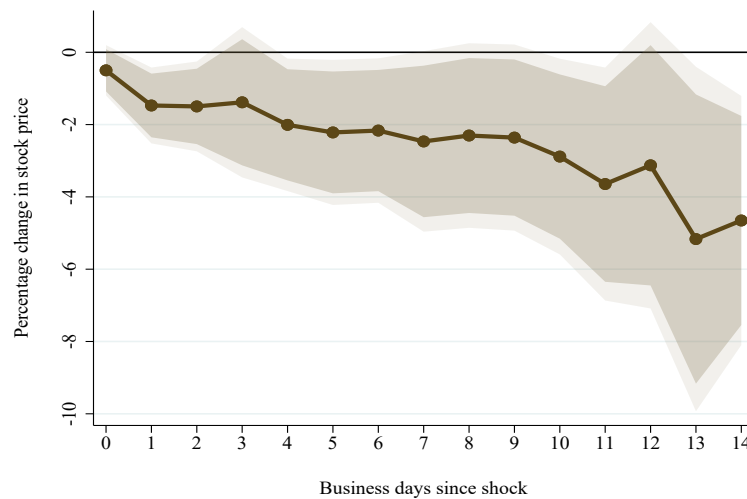
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.7: Response of non-US stock prices to US monetary policy: Scope 2 emission intensity



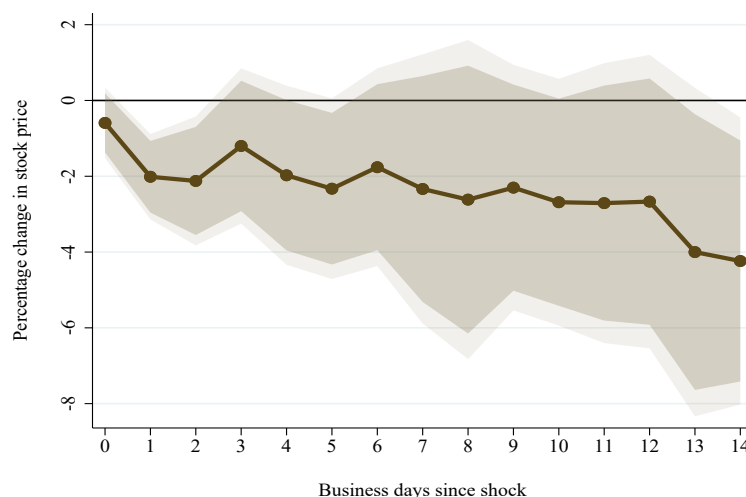
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.8: Response of non-US stock prices to US monetary policy: Scope 1 absolute emissions



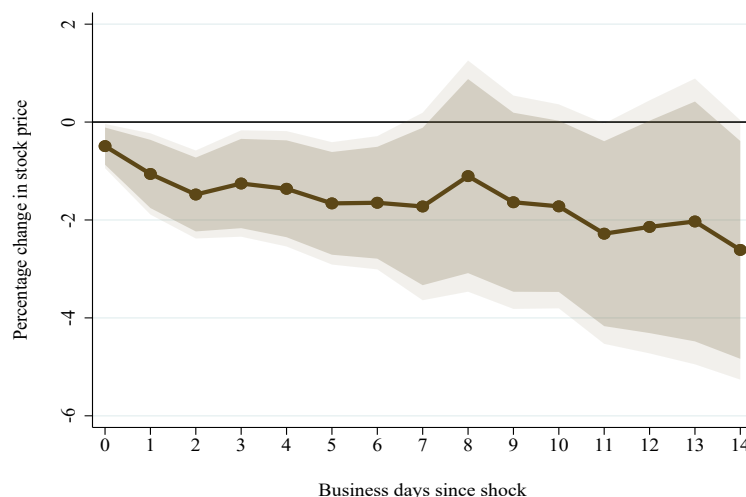
Notes: Dynamics of the interaction coefficient between absolute emissions and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.9: Response of non-US stock prices to US monetary policy: Scope 1 emission intensity (reporting only)



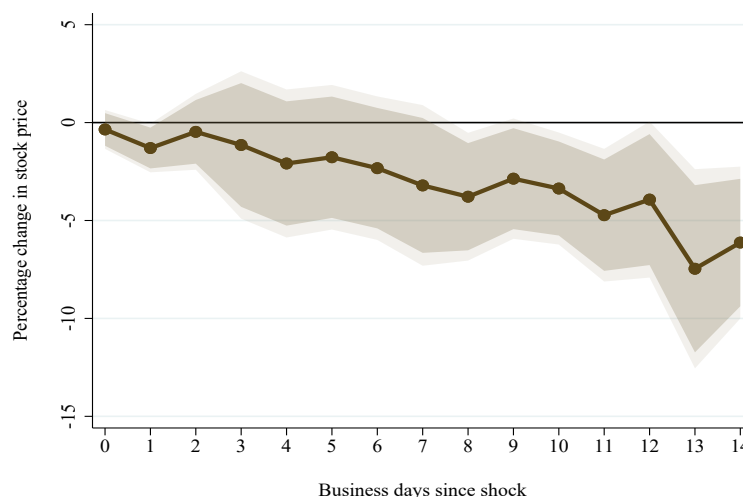
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.10: Response of non-US stock prices to US monetary policy: Scope 1 emission intensity (Advanced Economies)



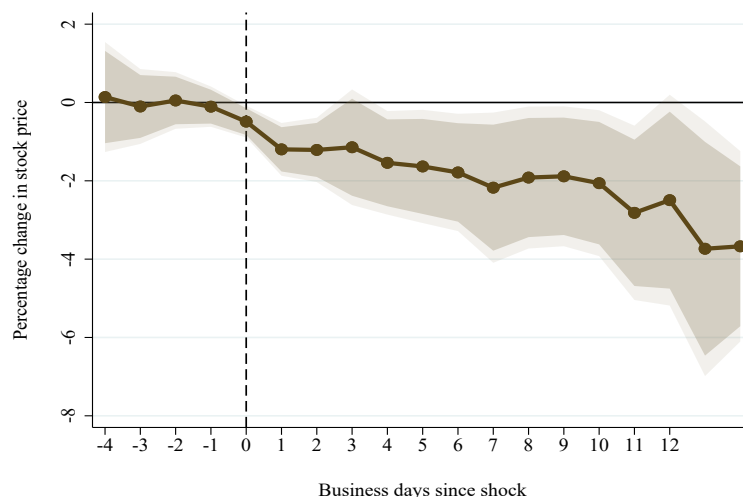
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.11: Response of non-US stock prices to US monetary policy: Scope 1 emission intensity (Emerging Market Economies)



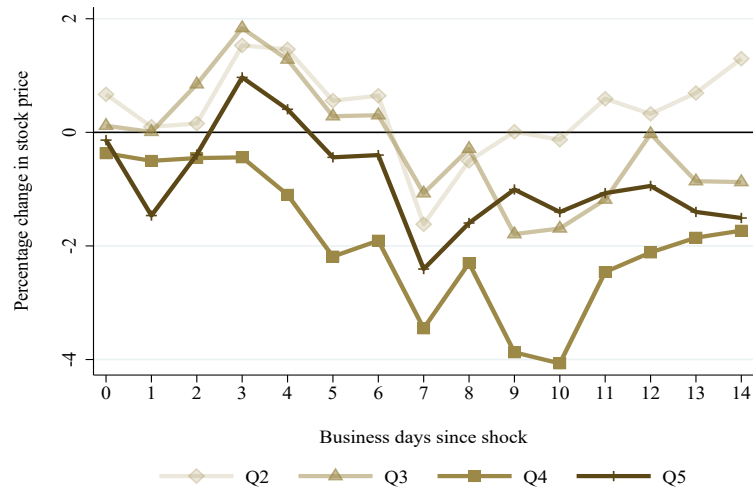
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.12: Response of non-US stock prices to US monetary policy: Scope 1 emission intensity checking pre-trend



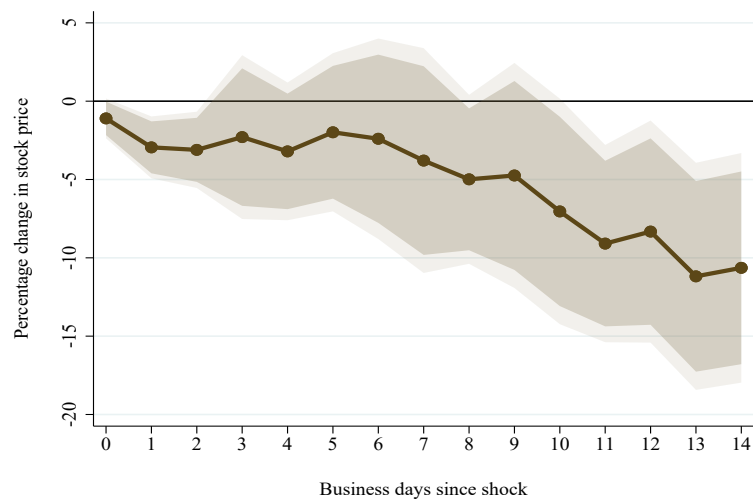
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.13: Response of non-US stock prices to US monetary policy: emission quintiles (Scope 1)



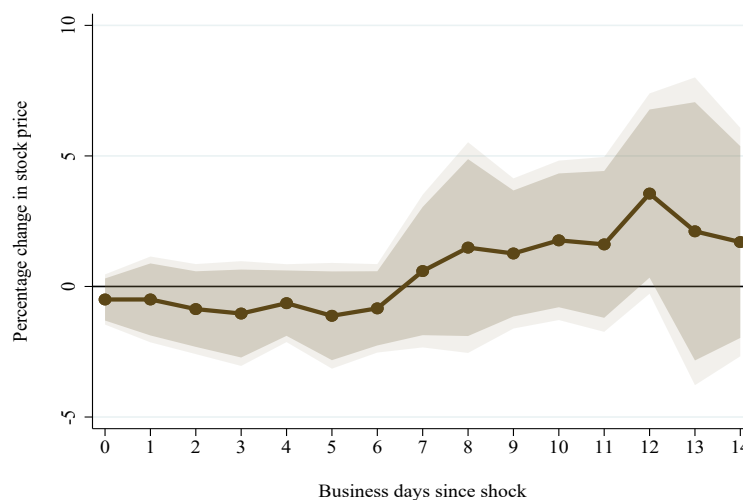
Notes: Dynamics of the interaction coefficient between brown dummy based on emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1), where the emission measure is a dummy for the quintile of the emission intensity distribution. The base group left out is the first quintile. Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.14: Response of non-US stock prices to US monetary policy: Scope 1 emission intensity with positive shocks only



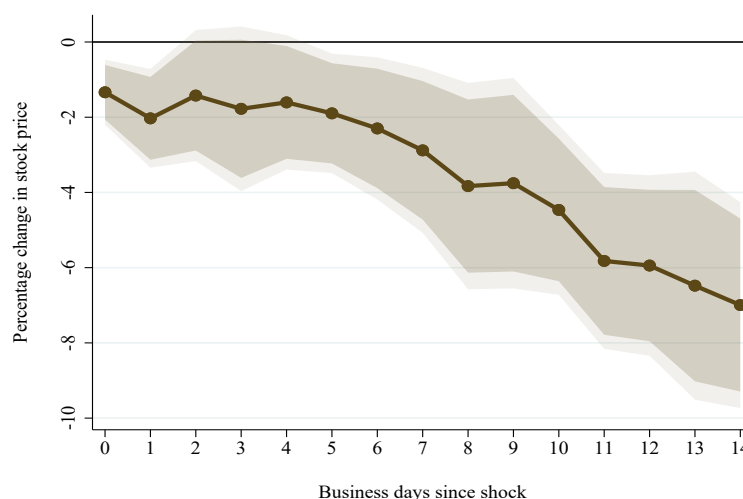
Notes: Dynamics of the interaction coefficient between emission intensity and positive monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.15: Response of non-US stock prices to US monetary policy: Scope 1 emission intensity with negative shocks only



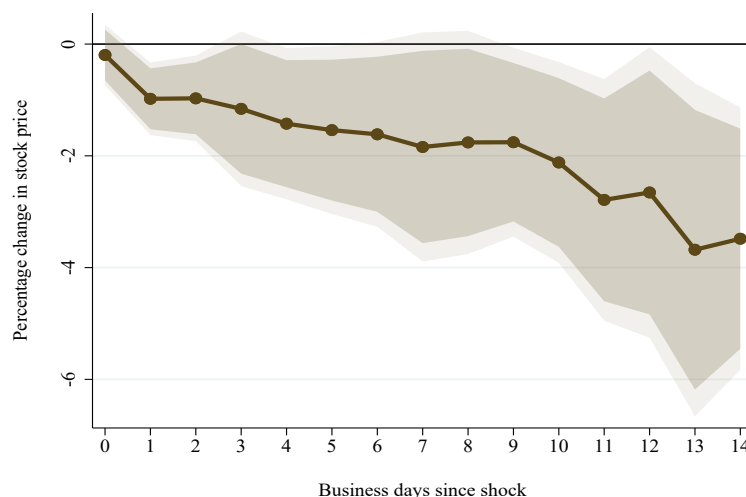
Notes: Dynamics of the interaction coefficient between emission intensity and negative monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.16: Response of non-US stock prices to US monetary policy: Scope 1 emission intensity with dividends per share as control



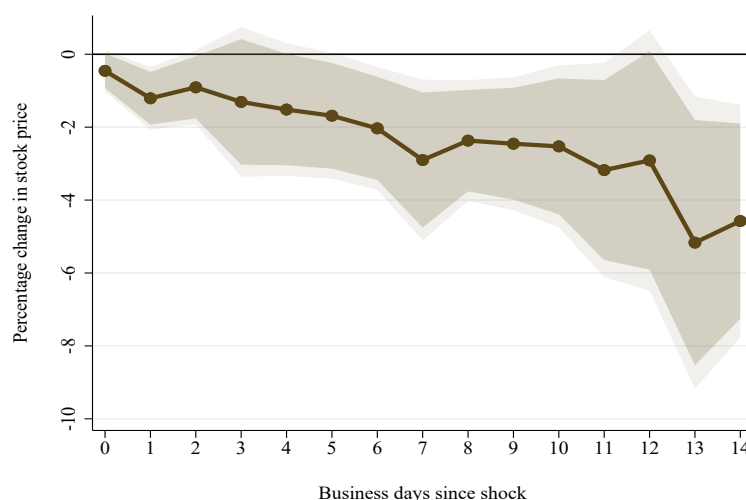
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.17: Response of non-US stock prices to US monetary policy: Scope 1 emission intensity with energy sector



Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

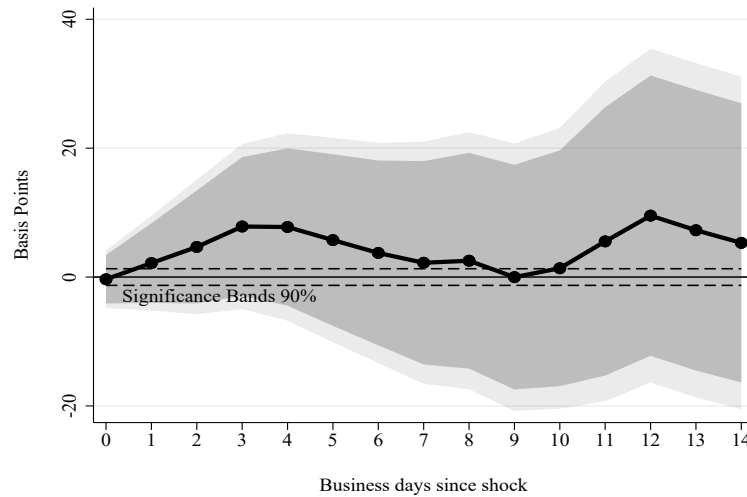
Figure C.18: Response of non-US stock prices to US monetary policy: Scope 1 emission intensity excluding double-listing in US and American Depositary Receipts



Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.1.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

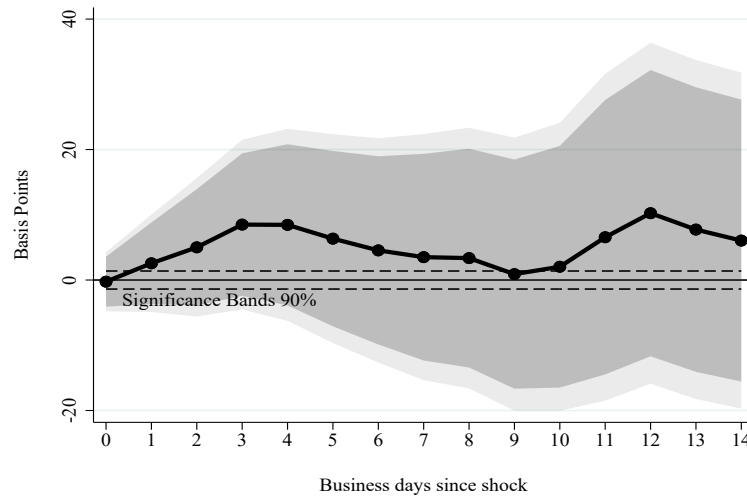
C.2.3 Credit Spreads

Figure C.19: Response of non-US bond spreads to US monetary policy: Average effect



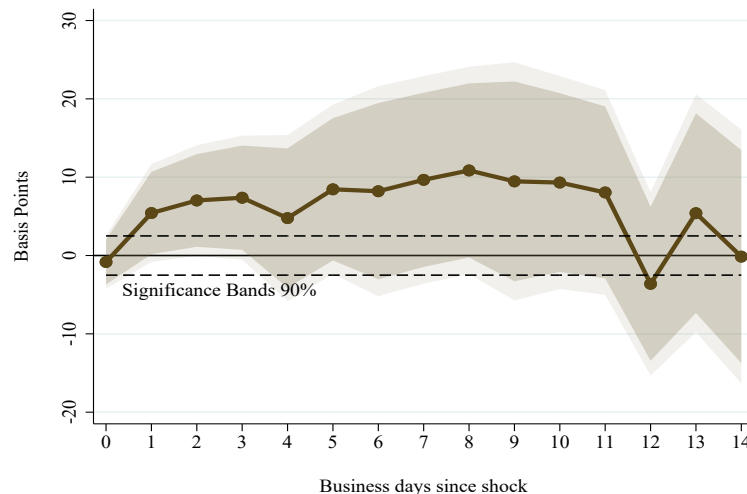
Notes: Dynamics of the coefficient on monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients for the average effect of equation (3.3.2.1) dropping time fixed effects. Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level. Significance bands for joint test are constructed using the Wild-Block Bootstrap (Inoue et al., 2025).

Figure C.20: Response of non-US bond spreads to US monetary policy: Average effect
- Advanced Economies only



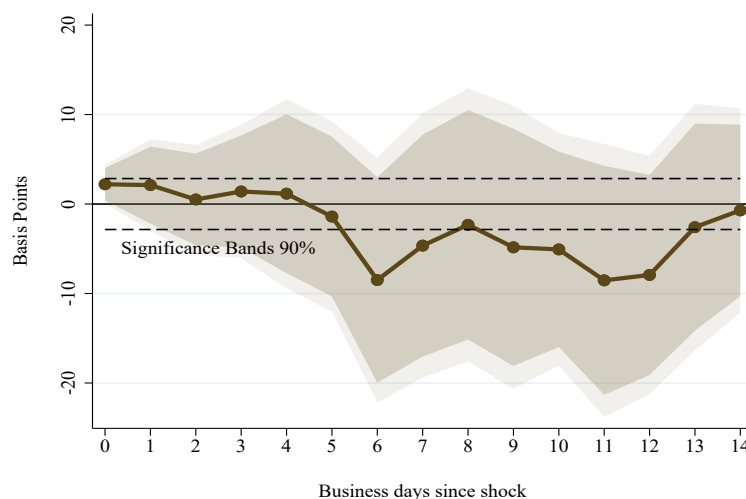
Notes: Dynamics of the coefficient on monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients for the average effect of equation (3.3.2.1) dropping time fixed effects. Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level. Significance bands for joint test are constructed using the Wild-Block Bootstrap (Inoue et al., 2025).

Figure C.21: Response of non-US bond spreads to US monetary policy (“Median Rotation” shocks): Scope 1 emission intensity



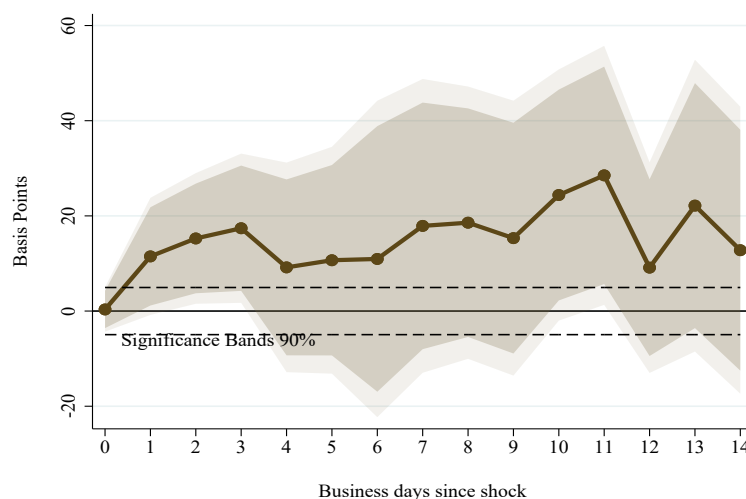
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.2.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level. Significance bands for joint test are constructed using the Wild-Block Bootstrap (Inoue et al., 2025).

Figure C.22: Response of non-US bond spreads to US monetary policy: Scope 2 emission intensity



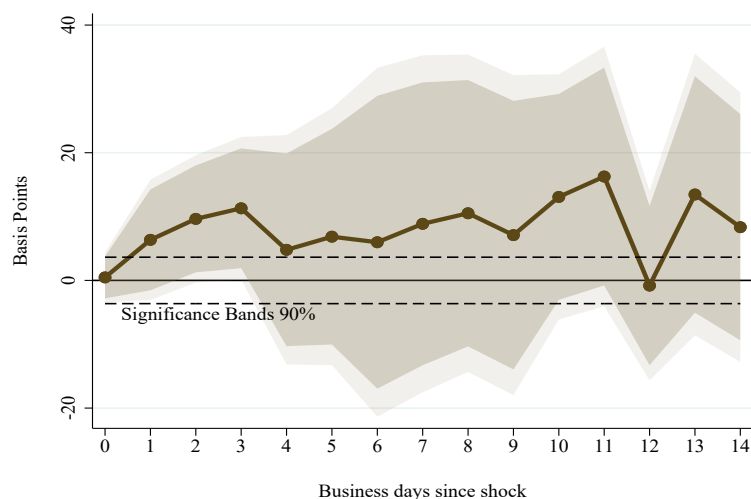
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.2.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level. Significance bands for joint test are constructed using the Wild-Block Bootstrap (Inoue et al., 2025).

Figure C.23: Response of non-US bond spreads to US monetary policy: Scope 1 absolute emissions



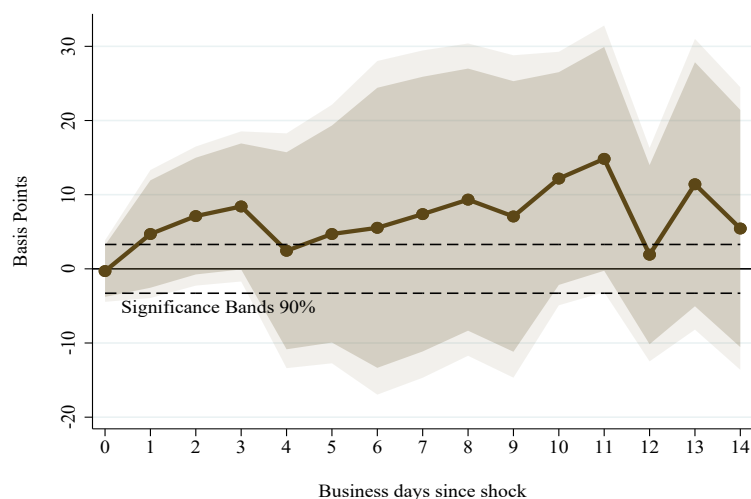
Notes: Dynamics of the interaction coefficient between absolute emissions and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.2.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level. Significance bands for joint test are constructed using the Wild-Block Bootstrap (Inoue et al., 2025).

Figure C.24: Response of non-US bond spreads to US monetary policy: Scope 1 emission intensity (reporting only)



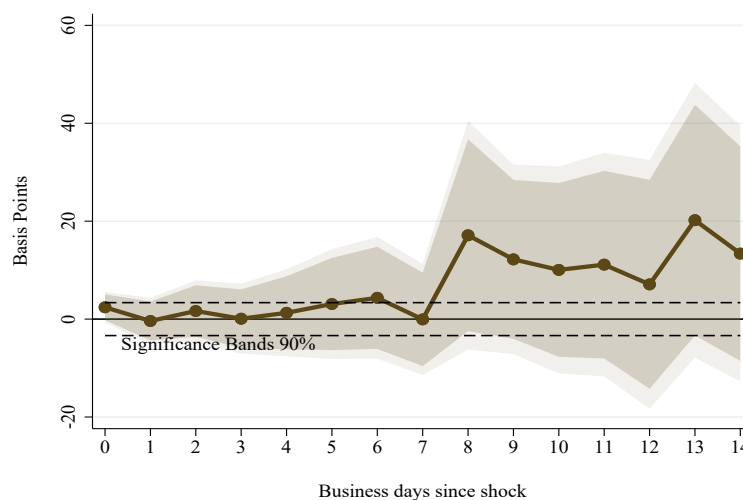
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.2.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level. Significance bands for joint test are constructed using the Wild-Block Bootstrap (Inoue et al., 2025).

Figure C.25: Response of non-US bond spreads to US monetary policy: Scope 1 emission intensity (Advanced Economies)



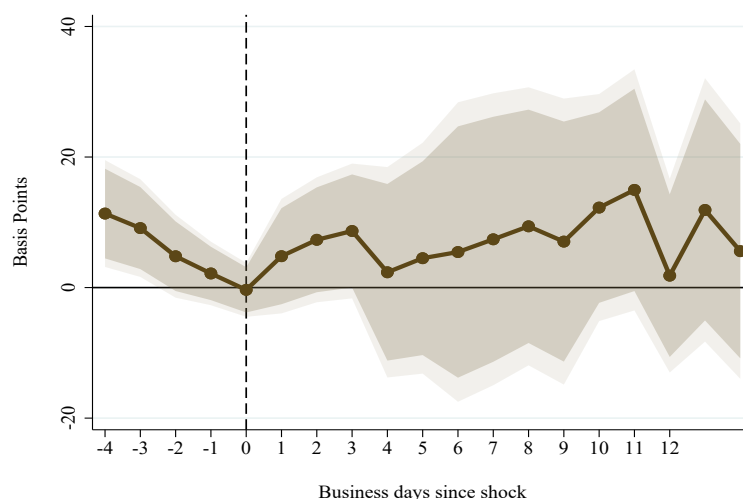
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.2.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level. Significance bands for joint test are constructed using the Wild-Block Bootstrap (Inoue et al., 2025).

Figure C.26: Response of non-US bond spreads to US monetary policy: Scope 1 emission intensity (Emerging Market Economies)



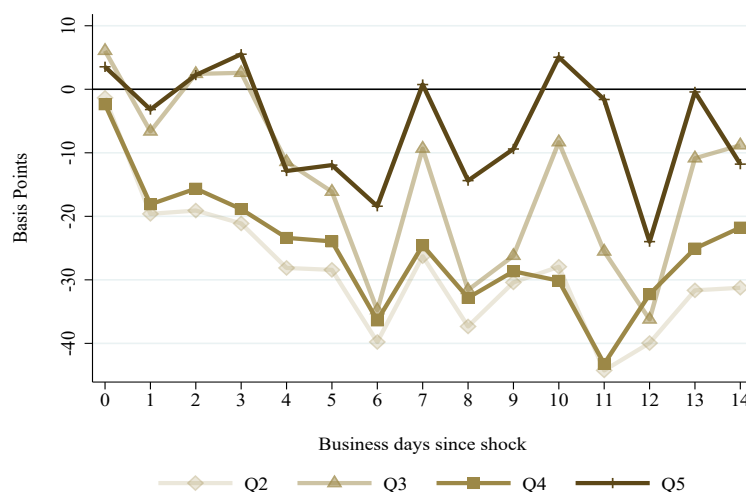
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.2.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level. Significance bands for joint test are constructed using the Wild-Block Bootstrap (Inoue et al., 2025).

Figure C.27: Response of non-US bond spreads to US monetary policy: Scope 1 emission intensity checking pre-trend



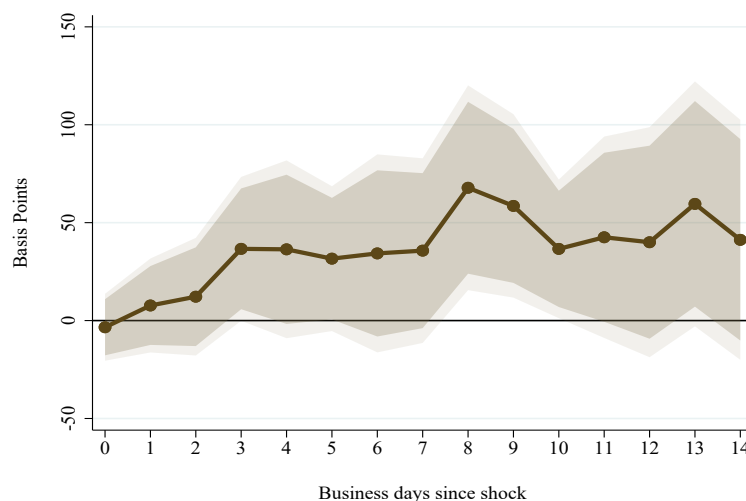
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.2.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.28: Response of non-US bond spreads to US monetary policy: emission quintiles (Scope 1)



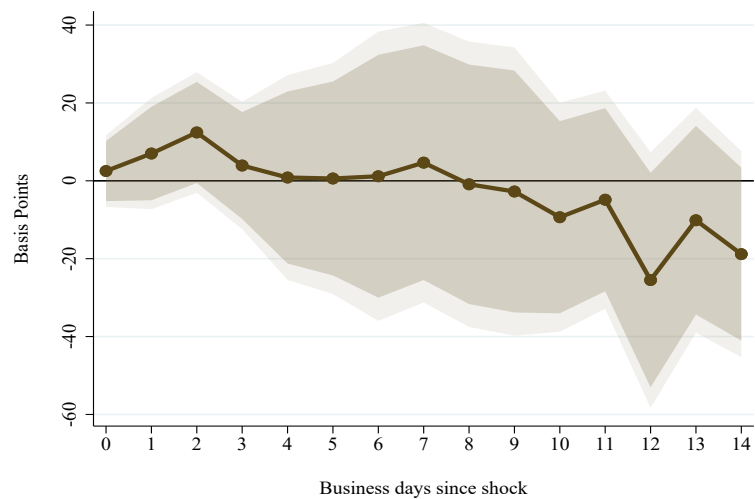
Notes: Dynamics of the interaction coefficient between brown dummy based on emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.2.1), where the emission measure is a dummy for the quintile of the emission intensity distribution. The base group left out is the first quintile. Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

Figure C.29: Response of non-US bond spreads to US monetary policy: Scope 1 emission intensity with positive shocks only



Notes: Dynamics of the interaction coefficient between emission intensity and positive monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.2.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

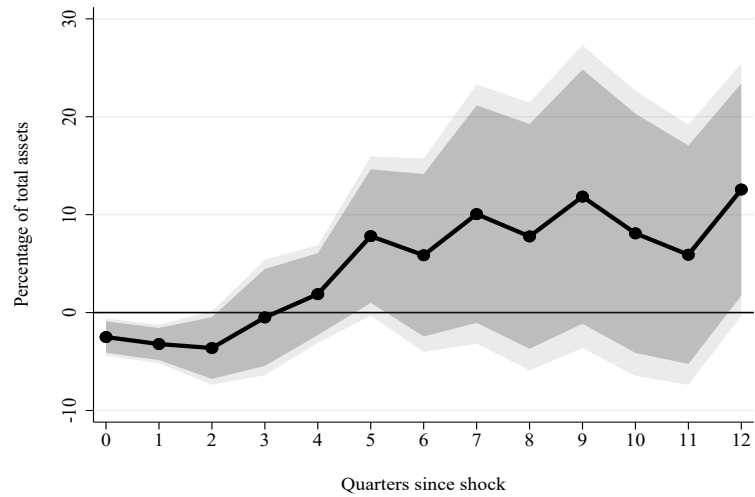
Figure C.30: Response of non-US bond spreads to US monetary policy: Scope 1 emission intensity with negative shocks only



Notes: Dynamics of the interaction coefficient between emission intensity and negative monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.2.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and event-day level.

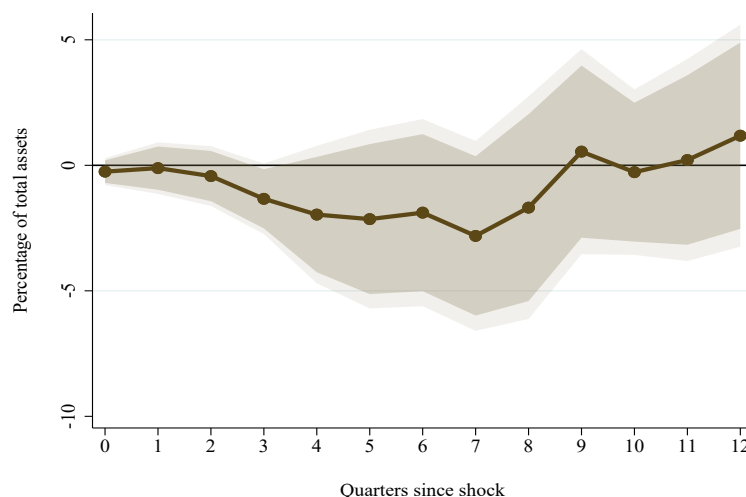
C.2.4 Debt

Figure C.31: Response of non-US firm-level debt to US monetary policy: average



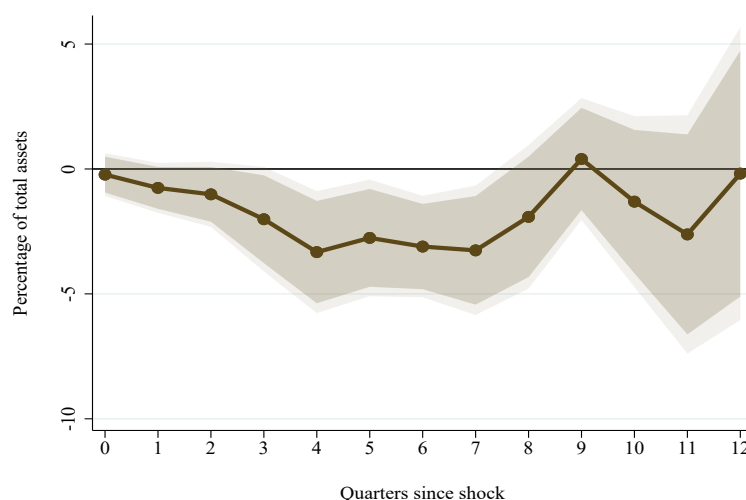
Notes: Dynamics of the coefficient on monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients for the average effect of equation (3.3.3.1) dropping time fixed effects. Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.32: Response of non-US firm-level debt to US monetary policy (“Median Rotation” shocks): Scope 1 emission intensity



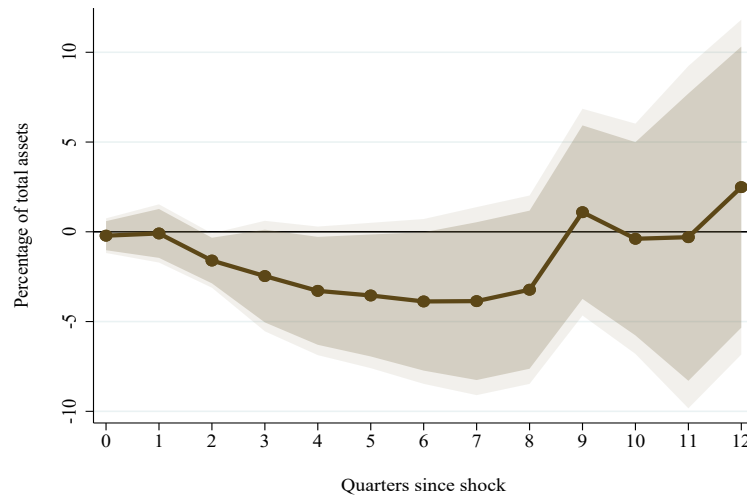
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.3.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.33: Response of non-US firm-level debt to US monetary policy: Scope 2 emission intensity



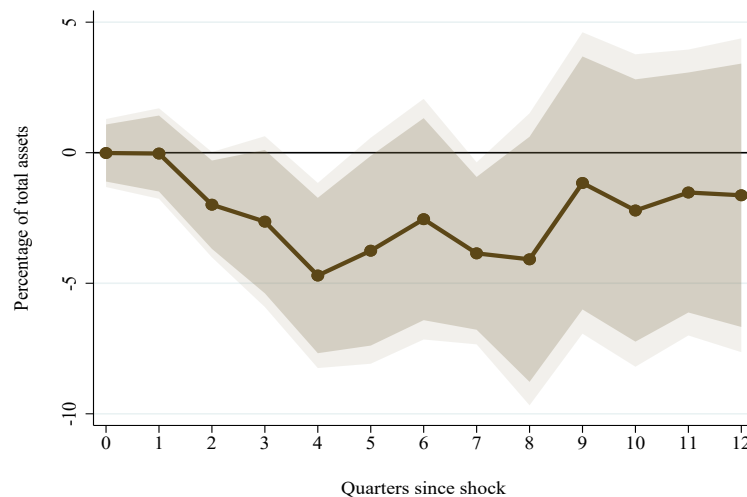
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.3.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.34: Response of non-US firm-level debt to US monetary policy: Scope 1 absolute emissions



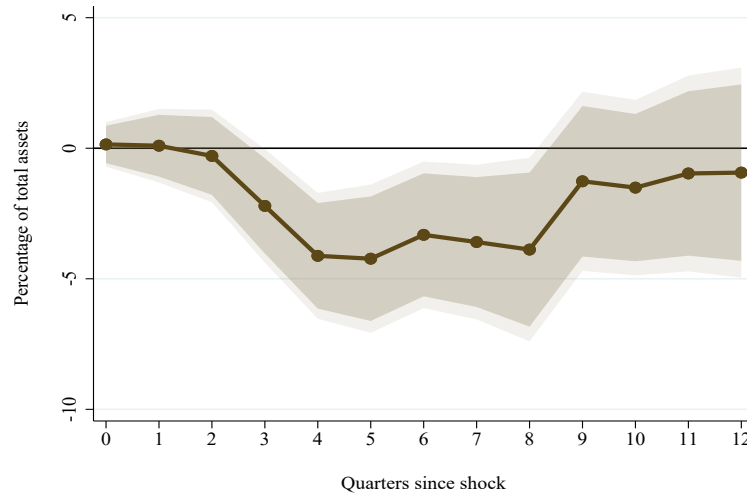
Notes: Dynamics of the interaction coefficient between absolute emissions and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.3.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.35: Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity (reporting only)



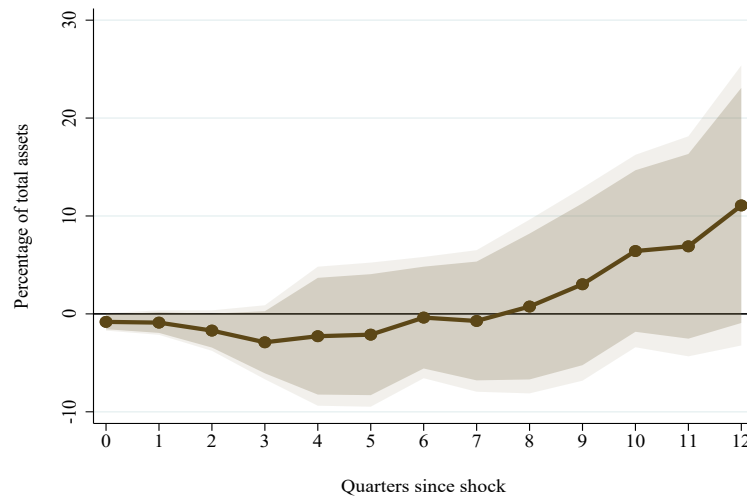
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.3.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.36: Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity (Advanced Economies)



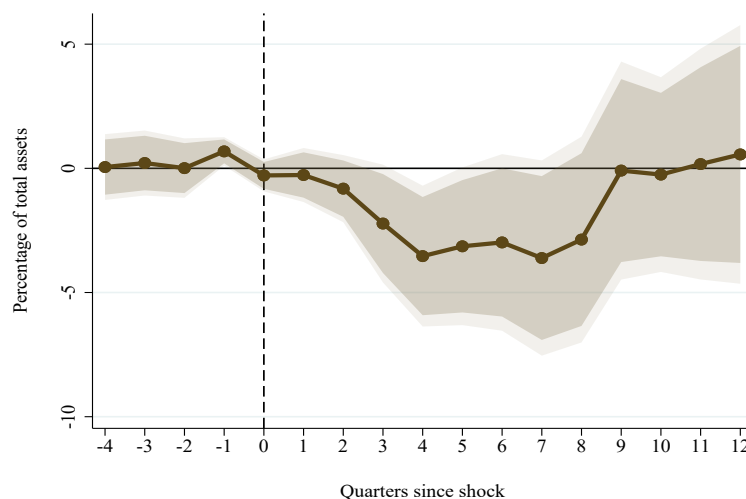
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.3.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.37: Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity (Emerging Market Economies)



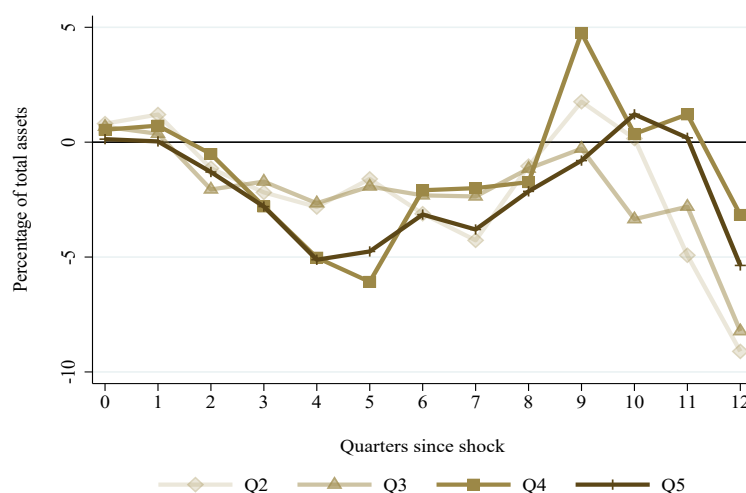
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.3.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.38: Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity checking pre-trend



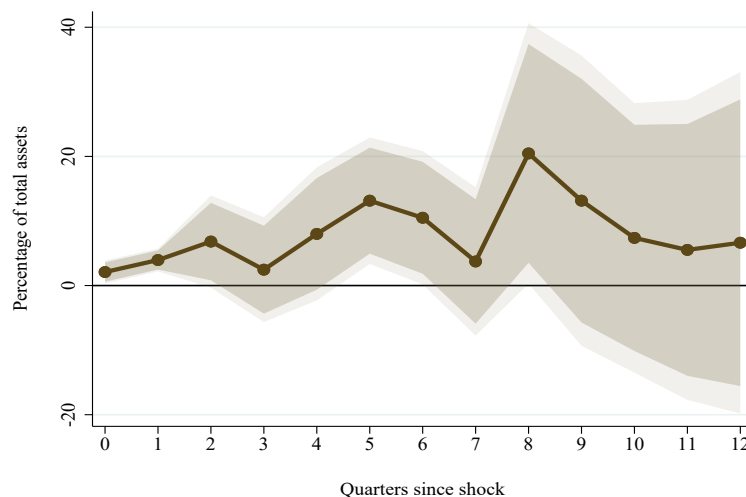
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.3.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.39: Response of non-US firm-level debt to US monetary policy: emission quintiles (Scope 1)



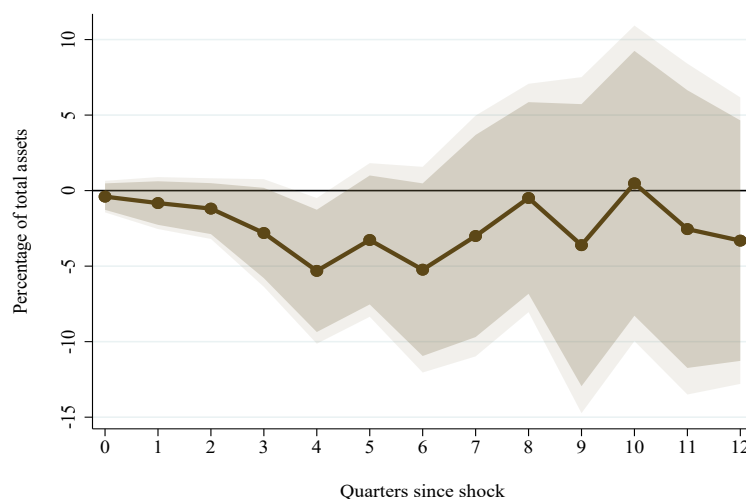
Notes: Dynamics of the interaction coefficient between brown dummy based on emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. Connected line reports the estimated coefficients β^h from equation (3.3.3.1), where the emission measure is a dummy for the quintile of the emission intensity distribution. The base group left out is the first quintile. Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.40: Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity with positive shocks only



Notes: Dynamics of the interaction coefficient between emission intensity and positive monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.3.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

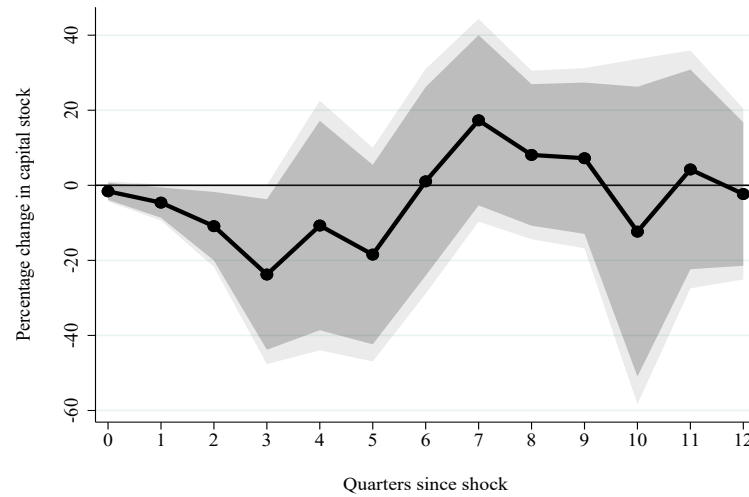
Figure C.41: Response of non-US firm-level debt to US monetary policy: Scope 1 emission intensity with negative shocks only



Notes: Dynamics of the interaction coefficient between emission intensity and negative monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.3.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

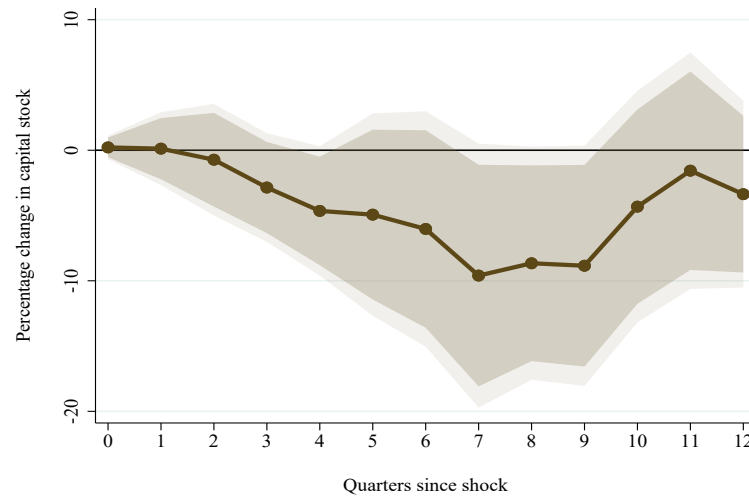
C.2.5 Investment

Figure C.42: Response of non-US firm-level investment to US monetary policy: average



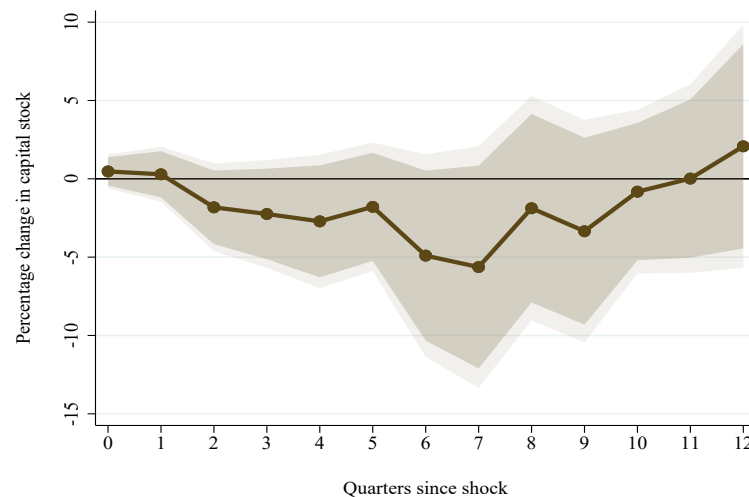
Notes: Dynamics of the coefficient on monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients for the average effect of equation (3.3.4.1) dropping time fixed effects. Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.43: Response of non-US firm-level investment to US monetary policy (“Median Rotation” shocks): Scope 1 emission intensity



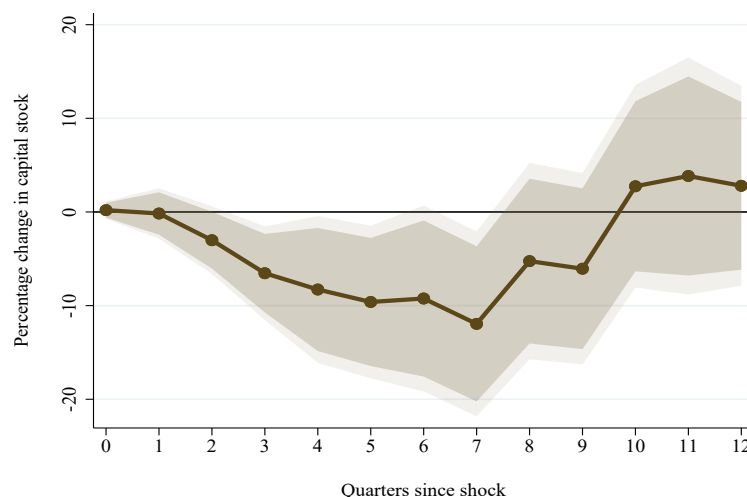
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.4.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.44: Response of non-US firm-level investment to US monetary policy: Scope 2 emission intensity



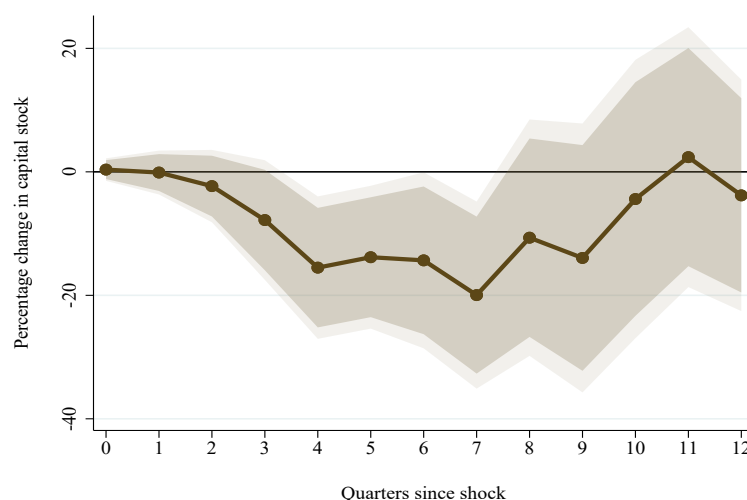
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.4.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.45: Response of non-US firm-level investment to US monetary policy: Scope 1 absolute emissions



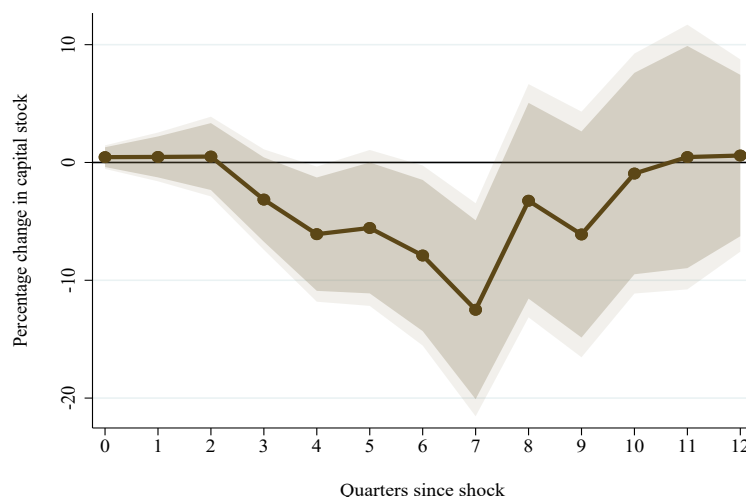
Notes: Dynamics of the interaction coefficient between absolute emissions and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.4.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.46: Response of non-US firm-level investment to US monetary policy: Scope 1 emission intensity (reporting only)



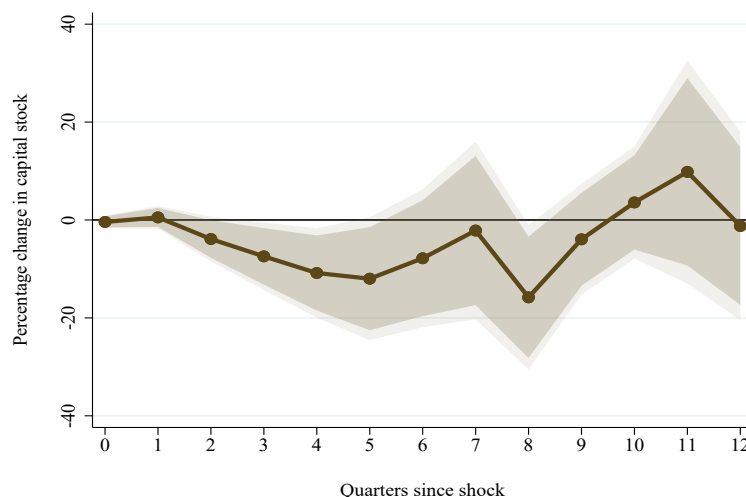
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.4.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.47: Response of non-US firm-level investment to US monetary policy: Scope 1 emission intensity (Advanced Economies)



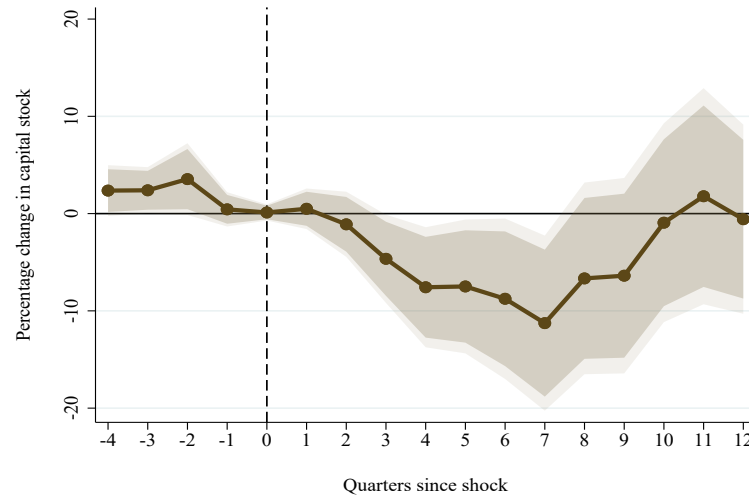
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.4.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.48: Response of non-US firm-level investment to US monetary policy: Scope 1 emission intensity (Emerging Market Economies)



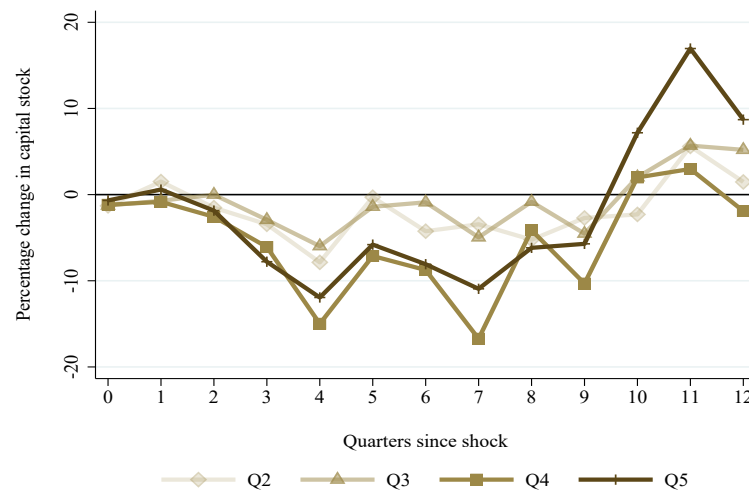
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.4.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.49: Response of non-US firm-level investment to US monetary policy: Scope 1 emission intensity checking pre-trend



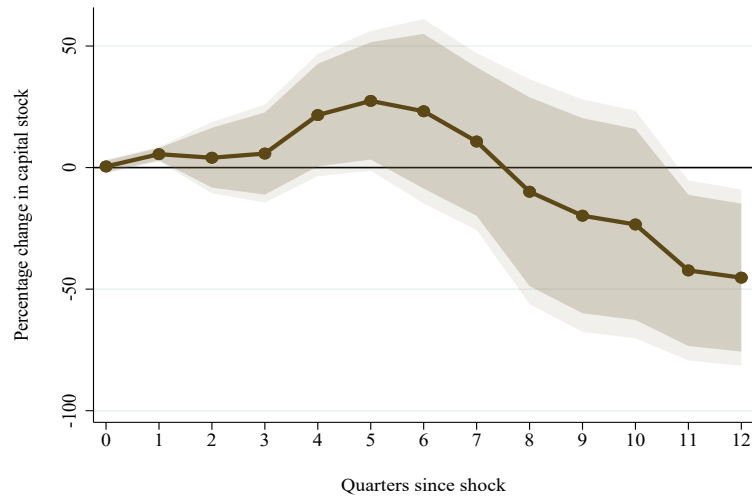
Notes: Dynamics of the interaction coefficient between emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.4.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.50: Response of non-US firm-level investment to US monetary policy: emission quintiles (Scope 1)



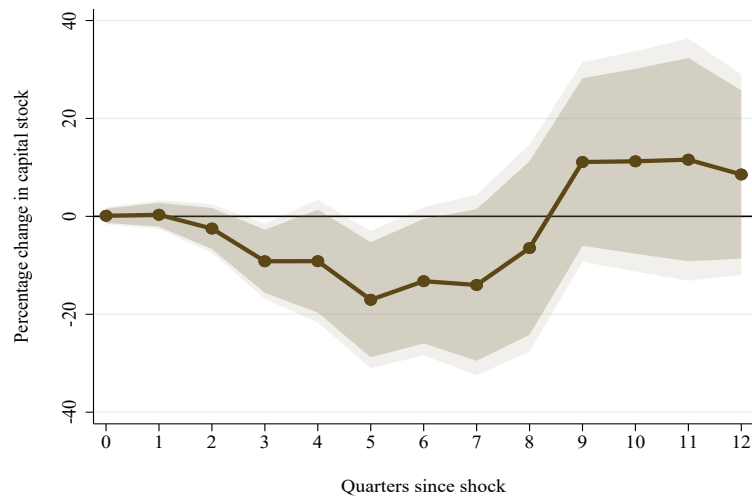
Notes: Dynamics of the interaction coefficient between brown dummy based on emission intensity and monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. Connected line reports the estimated coefficients β^h from equation (3.3.4.1), where the emission measure is a dummy for the quintile of the emission intensity distribution. The base group left out is the first quintile. Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

Figure C.51: Response of non-US firm-level investment to US monetary policy: Scope 1 emission intensity with positive shocks only



Notes: Dynamics of the interaction coefficient between emission intensity and positive monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.4.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

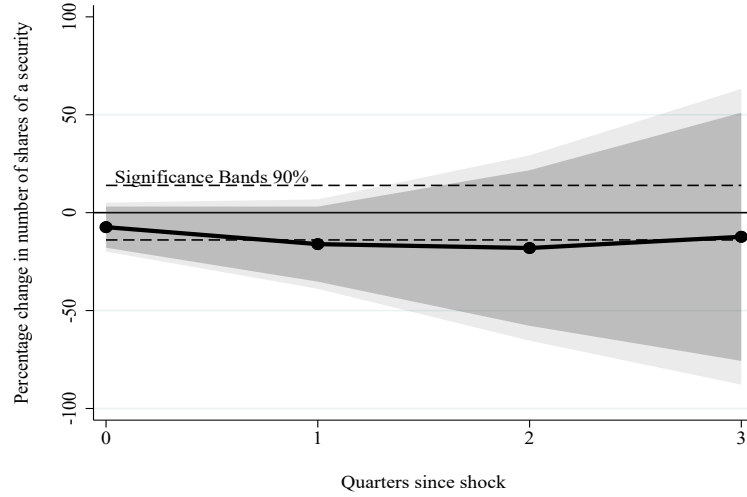
Figure C.52: Response of non-US firm-level investment to US monetary policy: Scope 1 emission intensity with negative shocks only



Notes: Dynamics of the interaction coefficient between emission intensity and negative monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. The connected line reports the estimated coefficients β^h from equation (3.3.4.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level.

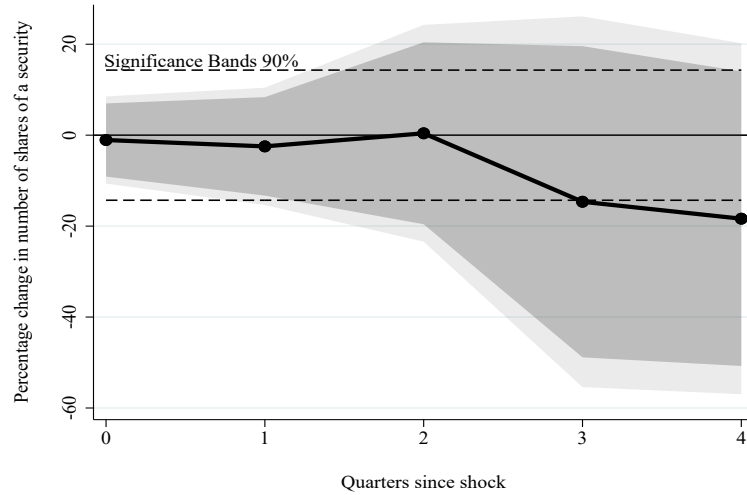
C.2.6 Mutual Funds

Figure C.53: Response of shares to US monetary policy: Average - ESG only



Notes: Dynamics of the coefficient on monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. Connected line reports the estimated coefficient β^h from equation (3.5.2.1). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level. Significance bands for joint test are constructed using the Wild-Block Bootstrap (Inoue et al., 2025)

Figure C.54: Response of shares to US monetary policy: Average - ESG and Non-ESG



Notes: Dynamics of the coefficient on monetary shocks over time. Shock normalised to be 25 basis points on the market yield on US Treasury Securities at 1-year constant maturity. Connected line reports the estimated coefficient β^h from equation (3.5.2.2). Two areas go from darker to lighter shades corresponding to 90% and 95% confidence intervals. Standard errors clustered at firm and quarter level. Significance bands for joint test are constructed using the Wild-Block Bootstrap (Inoue et al., 2025)

Monthly flows

For this analysis I use the CRSP mutual fund database, which is free from survivorship bias, and includes information on a fund’s monthly returns and total net assets, along with data on portfolio holdings, expense ratios, and associated fees, as well as other fund characteristics, such as its investment objective, fund family, type (e.g., equity, bond, hybrid), and founding date.² Given the focus of my analysis, I keep only funds that specialise in international investment in my sample.

I follow van der Beck (2023) to identify mutual funds with a potential “green bias”. I label a fund as an “ESG fund” if it exhibits at least one sustainability keyword in its name.³

Finally, following Patozi (2023) I compute capital flows for mutual fund i in month t as the net growth in i ’s total net assets $A_{i,t}$ adjusted for price changes through i ’s monthly return $r_{m,t}$ between $t - 1$ and t :

$$Flows_{i,t} = \frac{A_{i,t} - A_{i,t-1}(1 + r_{i,t})}{A_{i,t-1}} \quad (\text{C.2.6.1})$$

As fund’s returns within the month are accounted for, this measure accurately captures the net investments flowing in or out of the fund in that month.

To test the prediction from my model, I run the following panel regression:

$$Flows_{i,t+1} = \beta \cdot \varepsilon_t^M \times ESG_i + \gamma \cdot X_{i,t-1} + \alpha + \delta_{fund} + \delta_{mgmt,t} + \delta_{lipper,t} + u_{i,t} \quad (\text{C.2.6.2})$$

where ε_t^M is the monetary policy shock aggregated to a monthly frequency. Following Patozi (2023) the set of control variables $X_{i,t-1}$ includes the lagged term ESG_i , fund return, fund return 12-month-rolling volatility, fund size, fund age, a fund’s expense ratio, and an interaction of the monetary policy shock with the fund’s return volatility. $\delta_{c,t}$ represents management firm - time fixed effects (e.g., Vanguard, Blackrock, etc.), and $\delta_{s,t}$ controls for how funds of different types and with different investment strategies evolve over time. Fund types and investment

²I use this dataset because it covers also non-US assets, while other sources such as the data from 13F holdings for institutional investors considers only US equities.

³The considered keywords are: Environment, social, governance, green, sustainable, responsible, SRI, ESG, climate, clean, carbon, impact, fair, gender, solar, renewable, ethical, thematic, and conscious.

strategies are defined according to the Lipper classification system. This controls for the fund type (e.g., ETF, Index, or Mutual Fund) as well as the fund's investment objective (e.g., US Mid Cap Blend, Global Large Cap Blend, etc.). Finally, I saturate the regression and control for time-invariant fund-specific features adding fund fixed effects.

To begin with, I drop the time fixed effects from my baseline regression, so to be able to estimate the average effect across mutual fund's flows, as done in section 3.3. A monetary policy tightening appears to lower capital flows in line with what is found by Patozi (2023) considering a sample not focused on international investors (Table C.4). The estimated coefficients are mostly negative, but not always significant. This is likely to be a result of the smaller sample of mutual funds considered.

Table C.4: Mutual Fund International Flows - Average response to US monetary policy

	Equity			Index (equity)			Bond		
	(1) All	(2) Inst.	(3) Retail	(4) All	(5) Inst.	(6) Retail	(7) All	(8) Inst.	(9) Retail
Fed shock	-0.18 (0.15)	-0.08 (0.19)	-0.46** (0.23)	-0.55 (0.41)	-0.29 (0.41)	-2.18** (1.07)	0.03 (0.34)	0.62 (0.47)	-0.28 (0.39)
Observations	118104	64652	53220	16782	13084	3679	16704	8490	8214
R^2	0.092	0.079	0.116	0.099	0.098	0.139	0.091	0.087	0.090
Fund FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mgmt Firm FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lipper Class. FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fund Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: This table reports estimates of equation (C.2.6.2) where time fixed effects have been dropped in order to allow for the estimation of the coefficient on the monetary policy term, as well as its interaction with ESG mandate. Standard errors clustered at the fund and time level in parentheses with ***, ** and * denoting coefficients significantly different from zero at the 1, 5 and 10% levels, respectively. For more details on the monetary policy shocks used, see the notes to Figure 3.1.

Moving to my baseline specification, Table C.5 reports the estimated coefficients on the interaction term between the monetary policy shock and the indicator of ESG mandate proxying for green bias. Three main points emerge. First, in line with the attenuation mechanism in my model most of the coefficients are estimated to be positive. Second, estimates are statistically significant when considering all equity funds, where retail funds seem to be driving the results. Third, the reaction

Table C.5: Mutual Fund International Flows - Interaction ESG mandate & US monetary policy

	Equity			Index (equity)			Bond		
	(1) All	(2) Inst.	(3) Retail	(4) All	(5) Inst.	(6) Retail	(7) All	(8) Inst.	(9) Retail
ESG Mandate $\times$ Fed shock	0.29*** (0.09)	0.21 (0.15)	0.34** (0.17)	0.29 (0.27)	0.27 (0.29)	0.00 (.)	-0.06 (0.37)	0.00 (.)	-0.27 (0.39)
Observations	113867	58933	48947	15255	11564	2539	15632	6823	7463
R^2	0.237	0.247	0.349	0.337	0.323	0.554	0.322	0.347	0.496
Fund FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mgmt Firm-time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lipper-time FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fund Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: This table reports estimates of equation C.2.6.2. Standard errors clustered at the fund and time level in parentheses with ***, ** and * denoting coefficients significantly different from zero at the 1, 5 and 10% levels, respectively. For more details on the monetary policy shocks used, see the notes to Figure 3.1.

to monetary policy is not significantly different from the average for bonds investors — although the sample reduces substantially for those.

C.2.7 Syndicated Loans

In this section I report empirical evidence from international syndicated loans. I first describe the data and the empirical specification I employ to identify the effect of preferences for green investment. Finally, I present evidence of the attenuation channel predicted by my model to be at play.

Empirical Specification

As origination of syndicated loans is sporadic within a lender-borrower relationship, even when looking over a period of several years, I cannot use local projection methods in the same way I did for the analyses included in the main text. I thus run the following panel regression:

$$\begin{aligned} \ln(\text{New credit})_{blct} = & \beta_1 \varepsilon_{t-1}^M + \beta_2 \text{Emissions}_{b,t-1} + \beta_3 \cdot \varepsilon_{t-1}^M \times \text{Emissions}_{b,t-1} + \beta_4 \text{Committed}_{l,t-1} \\ & + \beta_5 \cdot \varepsilon_{t-1}^M \times \text{Committed}_{l,t-1} + \beta_6 \cdot \text{Emissions}_{b,t-1} \times \text{Committed}_{l,t-1} \\ & + \beta_7 \cdot \varepsilon_{t-1}^M \times \text{Emissions}_{b,t-1} \times \text{Committed}_{l,t-1} \\ & + \delta_{bt} + \delta_{lt} + \delta_{ct} + u_{blct} \end{aligned} \quad (\text{C.2.7.1})$$

where the dependent variable is the log of the total amount of new syndicated credit extended by lender l to borrower b denominated in currency c and originating in quarter t , based on the level of new loan issuance. As in section 3.3, ε_{t-1}^M is the quarterly sum of from Jarociński and Karadi (2020).

There is no established measure for climate-mindedness of lenders. I thus proceed by creating a comprehensive indicator combining several measures used by the literature on climate finance. Specifically, I classify lenders based on their green commitments by identifying those which have *ever* signed the PRI, TCFD, PRB⁴ and the SBTi⁵. The variable *Committed* is then equal to one for the whole

⁴Using syndicated loan data, G. Hale et al. (2024) show that all banks have decreased their exposure to loan-related emissions over the past eight years. However, they observe no significant difference between banks that publicly committed to these sustainability initiatives and those that did not — except for the early adopters of the PRI, who already exhibited lower emissions exposure in their syndicated lending activities.

⁵Using syndicated loans data and identifying committed lenders as those that had made pledges through the SBTi, M. T. Kacperczyk and Peydró (2022) show that companies with higher carbon footprint previously borrowing from those committed banks subsequently receive less bank credit.

sample, not just from the quarter the lender has committed to any of the initiatives. This should alleviate concerns of potentially varying control group with a staggered treatment such as this case. I then keep in my sample only those lenders without any commitments and those which have joined all of the initiatives in order to truly capture green preferences of the creditor.

The coefficient of interest β_7 therefore provides an estimate of how signatories' lending to higher and lower emitters changes relative to non-signatories' lending when US monetary policy tightens.

To identify this, I include tight sets of fixed effects: borrower-time fixed effects $\delta_{b,t}$ and lender-time fixed effects $\delta_{l,t}$ control for observed and unobserved time-varying borrower and lender characteristics respectively, including credit demand and any shocks to the supply of credit. Given the international dimension of my analysis, I also include currency-time fixed effects to control for drivers of cross-border flows such as exchange rates. Note that these sets of stringent fixed effects absorb the coefficients β_1 to β_5 and their corresponding terms.

I also add as a control a dummy equal to one if the lender is a non-bank institution — as its interaction with the monetary policy shock series. This has been shown to affect transmission of US monetary spillovers (Elliott, Meisenzahl and Peydró, 2024), as well as non-banks (banks) divesting relatively more (less) their credit provision abroad after a domestic shock, like a financial crisis (Aldasoro et al., 2022). Finally, standard errors are clustered by borrower, lender, currency and quarter.

An important challenge to identifying the differential credit supply response of green and brown lenders to US monetary policy is that, by definition, they lend to borrowers with different characteristics, and US monetary policy might affect the credit demand of these borrowers differently. As highlighted by Elliott, Meisenzahl and Peydró (2024) in the context of banks and non-banks, two features of the syndicated lending market allow us to cleanly isolate the credit supply response. First, syndicated loans involve multiple lenders to one borrower. This means that I can exploit within-borrower variation by comparing how different

institutions lend to the same firm.⁶ Secondly, although the borrower selects the lead arranger, the remaining lenders in the syndicate are chosen through a book-building process managed by the lead arranger, leaving the borrower with no influence over their selection.

Results

Table C.6 shows the results of this exercise.

First, as a validation of my approach, notice how my estimates for coefficient β_6 are negative and thus in line with the same results from M. T. Kacperczyk and Peydró (2022), which did not focus on monetary policy unlike this analysis.

Second, I estimate my coefficient of interest β_7 to be significantly negative when looking at both the intensive and extensive margin of lending, and across specification with increasing degrees of tightness of fixed effects. Unpacking this effect, column (4) and (5) reveal that it is driven by the extensive rather than intensive margin. This is further evidence that the green preference channel is at play: while the risk-taking channel acts through an increase in cost of borrowing and reduction in lending, a complete divestment as suggested by the prevalence of the extensive margin is more consistent with sustainable strategies linked to non-pecuniary green preferences in portfolio allocation.

Finally, notice the insignificant effect on maturity. This provides further evidence for green preferences as opposed to the risk-taking channel: if lenders were trying to hedge climate risk, which is a financial risk related to the medium to long term, maturity should decrease as it becomes harder for lenders to bear debt of transition-risky brown borrower after a US exogenous monetary tightening.

⁶As already mentioned, I use borrower-quarter fixed effects to control for time-varying borrower characteristics.

Table C.6: Syndicated Loans: Lenders' Commitment, Non-US Borrowers' Emissions & US monetary policy

	(1)	(2)	(3)	(4)	(5)	(6)
	Intensive+Extensive	Intensive+Extensive	Intensive+Extensive	Extensive	Intensive	Maturity
Emissions x Committed	-0.01*** (0.00)	-0.01*** (0.00)	-0.01*** (0.00)	-0.00*** (0.00)	0.00 (0.00)	0.00 (0.00)
MP Shock x Emissions x Committed	-0.25** (0.10)	-0.19*** (0.04)	-0.18*** (0.04)	-0.03* (0.02)	0.03 (0.13)	0.00 (0.05)
Observations	257264	256416	240244	240244	6790	6717
R^2	0.007	0.594	0.630	0.669	0.968	0.972
Lender FE	✓					
Borrower FE	✓					
Currency FE	✓					
Lender-Time FE		✓	✓	✓	✓	✓
Borrower-Time FE		✓	✓	✓	✓	✓
Currency-Time FE		✓	✓	✓	✓	✓

Notes: This table reports estimates for β_6 and β_7 of equation C.2.7.1. Standard errors clustered at the borrower-lender-currency-time level in parentheses with ***, ** and * denoting coefficients significantly different from zero at the 1, 5 and 10% levels, respectively. For more details on the monetary policy shocks used, see the notes to Figure 3.1.

C.3 Model

In this section I set out a more general version of my model from section 3.4 to show that its insights do not rely on the simplifying assumptions made in the main text.

C.3.1 General Set-Up

Consider a global investor who lives forever. She faces neither idiosyncratic nor aggregate uncertainty. Her financing in each period comes from her own net worth N and deposits d provided by households. If she sources deposits at time t , she must repay them the following period return R^d to depositors. As in the simpler model in the main text, financing rate R^d proxies for global financial conditions, which are affected by US monetary policy.

In every period t , the global investors uses her funds to buy two types of assets: green b^g and brown b^b securities, purchased at price Q and yielding return R in the next period $t + 1$.

The balance sheet identity in every period is thus

$$n_t + d_t = Q_t^g b_t^g + Q_t^b b_t^b \quad (\text{C.3.1.1})$$

and the expression for the profits on the investor's activity is just her net proceeds from her holdings after repaying depositors:

$$R_{t+1}^g Q_t^g b_t^g + R_{t+1}^b Q_t^b b_t^b - R_t^d d_t \quad (\text{C.3.1.2})$$

I now describe the two financial frictions in the model which characterise the global investor as a “sustainable” one: (i) preferences for green holdings and (ii) lower risk-bearing capacity for brown assets.

C.3.2 Green Preferences

The global investor derives direct utility from green holdings (Krishnamurthy and Vissing-Jorgensen, 2012). In this more general set-up I leave the functional form of the utility unspecified, i.e. $f(Q^g b^g)$.

This friction affects her maximisation problem. Specifically, she chooses asset holdings to maximise the discounted sum of both profits *and* utility in all periods:

$$V_t = \max_{b_t^g, b_t^b} \sum_{t=0}^{\infty} \left(\frac{1}{R_t^d} \right)^t \left\{ (R_{t+1}^g - R_t^d) Q_t^g b_t^g + (R_{t+1}^b - R_t^d) Q_t^b b_t^b + R_t^d n_t + f(Q_{t+1}^g b_{t+1}^g) \right\}$$

or with budget constraint $Q_{t+1}^g b_{t+1}^g = R_{t+1}^g Q_t^g b_t^g$:

$$V_t = \max_{b_t^g, b_t^b} \sum_{t=0}^{\infty} \left(\frac{1}{R_t^d} \right)^t \left\{ (R_{t+1}^g - R_t^d) Q_t^g b_t^g + (R_{t+1}^b - R_t^d) Q_t^b b_t^b + R_t^d n_t + f(R_{t+1}^g Q_t^g b_t^g) \right\} \quad (\text{C.3.2.1})$$

C.3.3 Pricing Climate Risk

At the beginning of every period, the global investor can choose to liquidate. If she does, then her depositors get only a fraction of her portfolio back. Formally, this leads to an incentive-compatibility constraint (Gertler and Karadi, 2011), whereby the investor will not liquidate as long as her continuation value V_t is larger than what she could run away with, that is the fraction of assets that depositors cannot claim back:

$$V_t \geq \theta Q_t^b b_t^b + \theta \Delta Q_t^g b_t^g \quad (\text{C.3.3.1})$$

Crucially, notice that in case of liquidation, depositors are left with fraction $1 - \theta$ of brown and a larger portion $1 - \theta \Delta$ of green holdings, as $0 < \theta < 1$ and $0 < \Delta < 1$.

This is a simple and convenient way to capture the differential exposure of green and brown assets to transition (credit) risk. Intuitively, as transition risk increases, i.e. as Δ decreases, and brown assets become relatively less *pledgeable* with respect to green ones in the constraint C.3.3.1.

C.3.4 Maximisation

The global investor thus chooses green and brown holdings to maximise (C.3.2.1) subject to (C.3.3.1).

The maximisation problem has the Lagrangian:

$$\begin{aligned} \mathcal{L} = \max_{b_t^g, b_t^b} \sum_{t=0}^{\infty} \left(\frac{1}{R_t^d} \right)^t & \left\{ [(R_{t+1}^g - R_t^d) Q_t^g b_t^g + (R_{t+1}^b - R_t^d) Q_t^b b_t^b + R_t^d n_t + f(R_{t+1}^g Q_t^g b_t^g)] (1 + \lambda) \right. \\ & \left. - \lambda \left\{ \theta Q_t^b b_t^b + \theta \Delta Q_t^g b_t^g \right\} \right\} \end{aligned} \quad (\text{C.3.4.1})$$

Using the chain rule⁷, the First Order Conditions for this problem are:

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial b_t^g} &: \left\{ f'(Q_t^g b_t^g) Q_t^g + \frac{1}{R_t^d} \left\{ (R_{t+1}^g - R_t^d) Q_t^g + f'(Q_t^g b_t^g) R_{t+1}^g Q_t^g \right\} \right\} (1 + \lambda) - \lambda \theta \Delta Q_t^g = 0 \\ \frac{\partial \mathcal{L}}{\partial b_t^b} &: \frac{1}{R_t^d} \left\{ (R_{t+1}^b - R_t^d) Q_t^b \right\} (1 + \lambda) - \lambda \theta Q_t^b = 0\end{aligned}$$

Rearranging and simplifying:

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial b_t^g} &: \left\{ f'(Q_t^g b_t^g) - 1 + [1 + f'(Q_t^g b_t^g)] \frac{R_{t+1}^g}{R_t^d} \right\} (1 + \lambda) - \lambda \theta \Delta = 0 \\ \frac{\partial \mathcal{L}}{\partial b_t^b} &: \left\{ \frac{R_{t+1}^b}{R_t^d} - 1 \right\} (1 + \lambda) - \lambda \theta = 0\end{aligned}$$

I obtain expressions for R^g and R^b :

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial b_t^g} : R_{t+1}^g &= R_t^d \left(\frac{1 - f'(Q_t^g b_t^g) + \frac{\lambda \theta \Delta}{1 + \lambda}}{1 + f'(Q_t^g b_t^g)} \right) \\ \frac{\partial \mathcal{L}}{\partial b_t^b} : R_{t+1}^b &= R_t^d \left(1 + \frac{\lambda \theta}{1 + \lambda} \right)\end{aligned}$$

C.3.5 Brown Premium: Risk and Preferences

Combining the expressions for the returns of the two assets, and assuming the constraint is always binding ($\lambda > 0$), I get the following equilibrium condition for the brown-green return spread:

$$R_{t+1}^b - R_{t+1}^g = R_t^d \left(1 + \frac{\lambda \theta}{1 + \lambda} - \frac{1 - f'(Q_t^g b_t^g) + \frac{\lambda \theta \Delta}{1 + \lambda}}{1 + f'(Q_t^g b_t^g)} \right)$$

and thus

$$R_{t+1}^b - R_{t+1}^g = R_t^d \left(\frac{(1 + \frac{\lambda \theta}{1 + \lambda})(1 + f'(Q_t^g b_t^g)) - (1 - f'(Q_t^g b_t^g) + \frac{\lambda \theta \Delta}{1 + \lambda})}{1 + f'(Q_t^g b_t^g)} \right)$$

Finally, rearranging the expression for the carbon differential return is:

$$R_{t+1}^b - R_{t+1}^g = R_t^d \left(\frac{2f'(Q_t^g b_t^g) + \frac{\lambda \theta}{1 + \lambda}(f'(Q_t^g b_t^g) + 1 - \Delta)}{1 + f'(Q_t^g b_t^g)} \right)$$

This condition states that the spread between brown and green returns in equilibrium is proportional to the deposit rate R^d .

⁷Note that $f'(Q_t^g b_t^g)$ is the derivative of f with respect to $Q_t^g b_t^g$, and $f'(R_{t+1}^g Q_t^g b_t^g)$ is derivative of f with respect to $R_{t+1}^g Q_t^g b_t^g$, which are of course the same $f'(Q_t^g b_t^g) = f'(R_{t+1}^g Q_t^g b_t^g)$ by definition.

C.3.6 Sustainable Investing and Monetary Policy

As the Federal Reserve increases US interest rates, this leads to tighter global financial conditions, and thus higher R^d in my model. What happens to the spread between brown and green assets?

Because $\lambda > 0$, $0 < \theta < 1$ and $0 < \Delta < 1$, the derivative of the spread with respect to R^d always has a positive sign, as long as $f'(Q_t^g b_t^g) \geq 0$, that is if more green holdings increase or do not affect utility:

$$\frac{\partial(R_{t+1}^b - R_{t+1}^g)}{\partial R_t^d} = \left(\frac{2f'(Q_t^g b_t^g) + \frac{\lambda\theta}{1+\lambda}(f'(Q_t^g b_t^g) + 1 - \Delta)}{1 + f'(Q_t^g b_t^g)} \right) > 0$$

This result is the same as the one in section 3.4 in the main text, and thus leads to the same conclusions. Furthermore, it shows that I can reconcile my empirical findings also with a more general model where I have relaxed several simplifying assumptions, including the functional form for green preferences.

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